_			Ex	posure					
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
/ei	r Dam Removal								
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom increased flow entrainment asimpoundment dewatering.Possible strandingof alevins in impoundment areas.Adults and juveniles:Mortality, injury, orstress from stranding or entrainment indewatering flows.Juveniles:Increased competition followingdisplacement, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration, resulting indecreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality juveniles and adults. Stress may aff survival, growth and fitness, and ad spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors und Water Quality Modification.

Table A-1. HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

,			Ex	posure	1		4		
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring	May affect survival at egg, alevin, a juvenile life-history stages. May aff spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to	flows. Encourage use of beaver deceivers.	
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal		decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased		
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous		survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous		Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
-	Ecosystem Fragmentation								
F	Riverine	1	Γ		T		1		T
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	growth and decay is most extensive)						
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

			Ex	posure								
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, alevin, a juvenile life-history stages. May aff spawning productivity.			
		Reduced foraging opportunities and rearing habitat availability					dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.					
	Aquatic Vegetation Modification											
- 1	Riverine											
Ļ	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.			
							survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.					
	Riparian Vegetation Modification											
	Riverine			1		T						
	Altered stream bank and shoreline stability	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.			
		Spawning gravel sedimentation					related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.					
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.			
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins;	<u>All exposed life-history stages</u> : See related stressor responses under Water	Replant former impoundment with native vegetation to discourage	See effects for related stressors under Water Quality Modificati			

Table A-1	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

•.			Exj	posure	-	-			
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	orm Response to Stressor Minimization Measures	Minimization Measures	Resulting Effects of the Submechanism
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modificatio
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult surviva productivity, and spawning success.

HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

			Ех	kposure	ŕ	1		
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
em	Woody Debris ent/Movement/Re nstruction impact	emoval (for placement ts apply)						
	Construction and Maintenance Activities							
	Riverine, Lacustrine, Marine							
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu cont wate work
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoi impa NOA habit drivi Use o reduc confi Encc and v Limi mach

Minimization Measures

Resulting Effects of the Submechanism

efuel and service machinery in a ontrolled environment away from the ater body. Limit heavy machinery ork within the project area.

void pile-driving noise in excess of npact thresholds established by IOAA Fisheries and USFWS in abitats used by species. Limit pile riving to in-water work windows. (se double-confined bubble curtain to educe sound pressure, or work within onfined or dewatered work areas. ncourage use of vibratory hammers and wooden pilings where practicable. imit in-water use of heavy nachinery. May affect survival, growth, and fitness of juveniles and adults.

May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Sub-			Exj	posure			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs and alevins, juveniles</u> : Injury or mortality from entrainment or impingement.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.

HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced

spawning productivity.

Minimization Measures	Resulting Effects of the Submechanism
Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition		Year round	Permanent	Continuous		competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

Table A-1	(continued).
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Sub-			Exj	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	d web stressor exposure	Permanent	Continuous	sediment supply, substrate groundwater inputs are core processes and characteristic nearshore ecosystem. Alter more of these parameters ca alter marine littoral habitats decreasing the suitability of juvenile Chinook salmon. through a number of specifi including increased exertion change in current and wave	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities Altered sediment supply		Year-round (with variable effects depending on site- specific current dynamics and project configuration)		Intermittent		alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction	patterns, and wave energy and current patterns.	
			Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.		

Table A-1	(continued).
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			Exj	posure						
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Lacustrine									
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats,	velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration		May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivi
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common			patterns, and wave energy and current patterns.		
	Altered sediment supply		Year-round	Permanent	Continuous					
	Altered substrate composition		Year-round	Permanent	Continuous					
	Ecosystem Fragmentation									
F	Riverine		X 1/							
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modificatio	
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.	

Table A-1	(continued).
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Sub-				Exposure			_					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat	Reduced availability of off- channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density- dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. <u>Juveniles</u> : Decreased refuge habitat	Requ hydr befo desig of flo long				
	connectivity	habitats along longitudinal gradient.					availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. <u>Adults:</u> Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.					
	Marine											
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid proje cumu preva				
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Enco perm habit				
	Lacustrine											
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requ footp objec in are effect				
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Enco perm habita				

Minimization Measures	Resulting Effects of the Submechanism
equire assessment of the draulic effects of the project fore permitting; avoid permitting signs that lead to disconnection floodplain habitat or ngitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile life- history stages. May affect adult survival and spawning productivity.
yoid permitting LWD removal ojects in areas where significant mulative effects are already evalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
courage project designs that limit rmanent alteration of high-quality bitat features.	May affect juvenile survival.
quire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
courage project designs that limit rmanent alteration of high-quality bitat features.	May affect juvenile survival.

Table A-1	(continued).
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Sub-			Ех	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Aquatic Vegetation Modification							-
	Marine							
	Altered autochthonous production	1 2		Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Const distur during
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	
	Riverine and Lacustrine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Const distur during
l		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	

Minimization Measures	Resulting Effects of the Submechanism
Construction: Avoid/minimize isturbance of aquatic vegetation uring project construction.	May affect juvenile growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival. May affect adult growth and spawning productivity.
Construction: Avoid/minimize isturbance of aquatic vegetation uring project construction.	May affect juvenile growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

)-		posure	1						
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification	-	-	•			-	-	
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due towinter ice formation and scour.Juveniles:Altered growth and survivalcaused by temperatures outside optimalgrowth range and alteration of food webpatterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning succes and overall population productivity.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. <u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.

Sub- activity Type			Ex	posure				
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Marine							
activity Type N A a	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoi ripari appro the g
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoi ripari appro the g
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chinook dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, Chinook are known to utilize terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoi ripari appro the g
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Enco perm habit
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chinook dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoi shore

Resulting Effects of the Submechanism
May affect juvenile growth and survival.
May affect juvenile survival.
May affect juvenile growth and fitness.
May affect juvenile survival.
Effects of the action resulting from this impact mechanism are unknown.

			Exj	posure	1				
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine	-				-	-	-	
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated habitats may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chinook are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitne
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chinook dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along the shoreline.	Effects of the action resulting from the impact mechanism are unknown.

ıb-			Ex	posure					
tivity /pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification					-			
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg and alevins. May affect juvenile survival, growth, and fitness, and ad survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

b-			Ex	posure					
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
pawr	ning Substrate Aug	mentation							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific nois disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pil- driving) may lead to direct mortali injury limiting to survival.

			Ex	posure	i.	·			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids	During project construction	Temporary to short-term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitne See effects for related stressors on al life-history stages under Water Qual Modification.
	Hydraulic and Geomorphic Modification								
-	Riverine		Τ	1	T	Т			Γ
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning succe and overall population productivity
							availability of suitable migratory and spawning habitat.		

			Ex	posure					
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects) Altered substrate composition/stability	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term Short-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. <u>Juveniles</u> : Altered channel geometry, bank stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	May affect survival at egg, alevin, a juvenile life-history stages. May at spawning productivity.
	Aquatic Vegetation Modification								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, grown and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.		

ıb-			Ex	posure				
tivity 7pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification	•	-		-		-	-
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini to ch short back pract proto turbi
n-Cha	annel/Off-Channel	Habitat Creation/Modific	cation					
	Maintenance Activities							
	Riverine							
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate work

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
fuel and service machinery in a ntrolled environment away from the ter body. Limit heavy machinery rk within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.

Sub-			Ех	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Insta cons Adhe work juver
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhe work egg i
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limi great
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoi back

Table A-1 (continued).

Minimization Measures	Resulting Effects of the Submechanism
stall and maintain pump screens nsistent with WDFW protocols. lhere to system-specific in-water ork windows, avoid use when veniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
there to system-specific in-water ork windows. Avoid work during g incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
mit area of dewatering to the eatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
void turbidity effects above ckground levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-			Ex	posure	ŕ	1		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification		-	-	-		-	
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu minit to ch short back pract proto turbi
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr water work

Riparian Planting/Restoration Enhancement

Riverine , Lacustrine, Marine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Mir spec assu spec

Minimization Measures	Resulting Effects of the Submechanism
nsure project design avoids and/or ninimizes habitat alterations leading o chronic bank instability. Avoid nort-term turbidity effects above ackground levels to greatest extent racticable. Adhere to established rotocols for managing sediment and irbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
efuel and service machinery in a ontrolled environment away from the vater body. Limit heavy machinery vork within the channel.	May affect survival, growth, and fitness of juveniles and adults.
finimize disturbance during invasive pecies removal. Use measures to ssure rapid establishment of planted pecies.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minin specie erosio after c
	Aquatic Vegetation Modification							
	Riverine, Lacustrine, Marine							
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Desig canop contin

Minimization Measures	Resulting Effects of the Submechanism
inimize disturbance during invasive eccies removal. Use appropriate osion control BMPs both during and er construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
sign riparian patches with variable nopy coverage so that sunlight will ntinue to reach the channel.	May affect juvenile growth and fitness

Table A-1	(continued).
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ub-			Ex	posure					
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification		-						
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

)- vity			Ex	posure	1	<u></u>			
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
tla	nd Creation Restor	ration/Enhancement							
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortalit injury limiting to survival.

Table A-1 (continued).	Table A-1	(continued).
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- vity			Exj	posure	[1			Resulting Effects of the
e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality juveniles and adults. Stress may aff survival, growth and fitness, and ad spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury juvenile life-history stage. Injury ar stress may affect survival, growth, a fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affe adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-			Ex	posure	·			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu minii to ch short back pract proto turbi
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr water work

Beach Nourishment/Contouring

Construction and Maintenance Activities							
Marine and Lacustrine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contre water mach projec
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid produ comm

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
fuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the channel.	May affect survival, growth, and fitness of juveniles and adults.
fuel and service machinery in a ntrolled environment away from the tter body. Limit heavy achinery/vessel work within the oject area.	May affect survival, growth, and fitness of juveniles and adults.
void project sites which are oductive and have a healthy benthic mmunity.	May affect growth and fitness at juvenile life-history stage.

y		Exposure					4		Demiking Fifthered
ſ	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification		-	-					
	Marine and Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project sites which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine and Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover					survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	productive, vegetated aquate nabiat.	
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating and alevins. May affect juvenile growth and fitness and adult productivity and spawning success
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

ub-			Ex	posure	Ţ	r	4	
ctivity `ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Reef C	Creation/Restoratio	n/Enhancement						
	Construction and Maintenance Activities							
	Marine and Lacustrine							
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions: may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoi perio prese
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	J <mark>uvenil</mark> es; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoi noise equij techi
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoi prod com

Minimization Measures	Resulting Effects of the Submechanism
roid construction activities during riods when individuals may be esent, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
roid/minimize cavitation to limit ise intensity. Promote use of vessels uipped with antinoise/antivibration hnology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
roid project sites which are oductive and have a healthy benthic mmunity.	May affect growth and fitness at juvenile life-history stage.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification		-	-	-	-	-	-	-
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. <u>Adults</u> : Adult Chinook salmon forage in nearshore environments during return migrations. Alteration of nearshore habitat characteristics through these sub-mechanisms may lead to decreased food web productivity and prey availability. This may lead to decreased growth and decrease spawning fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and fitness,
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				and spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-1	(continued).
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			Exposure						
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project Alteration an sediment supply, longshore drift patterns, and wave energy and current patterns. abitat for recur rs,	May affect survival at juvenile life- history stage. Decreased fitness ma lead to reduced spawning production
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to		
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging		
	Altered sediment supply		Year-round	Permanent	Continuous		opportunity, and increased competition for suitable habitats. The combined effect of		
-	Altered substrate composition	Year-round Permanent Continuous	Continuous		these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Chinook will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.				
	Ecosystem Fragmentation								
	Marine								
-	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, grow and fitness.
ĺ	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, grow and fitness.

Sub-Exposure activity **Mechanism of Impact** Stressor When Duration Frequency Life-history Form **Response to Stressor** Туре Aquatic Vegetation Modification Marine Altered cover and habitat Decreased refuge and forage habitat Year-round Short-term to Continuous Juveniles; Juveniles: Decreased refuge habitat Av availability and foraging opportunities, permanent veg Adults (dependent on nature leading to increased competition and of activity) predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity. Lacustrine Altered autochthonous Reduced foraging opportunities Year-round Short-term to Continuous Juveniles; Juveniles: Decreased refuge habitat Av availability and foraging opportunities, production permanent veg leading to increased competition and resulting (dependent on nature Altered cover and habitat effects on growth and fitness. of activity) Water Quality **Modification** Altered suspended solids Increased suspended solids Dependent on Temporary to short-Intermittent to Juveniles; Juveniles and adults: Responses vary Ca contributing term (dependent on interannual-decadal depending on stressor magnitude. des Adults mechanism of impact contributing (dependent on Unavoidable extreme turbidity may cause im mechanism of contributing physical injury and/or physiological effects pro impact) mechanism of (e.g., gill trauma, altered osmoregulation, des impact) blood chemistry changes). Moderate to high sed turbidity may cause behavioral alteration (e.g., pat avoidance responses) leading to increased pat territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success. Altered pollutant loading Leaching of toxic substances Year-round Intermediate-term Continuous with Juveniles: All affected life-history stages: Physiological Use seasonal pulses (depending on composition of reef responses to exposure at toxic levels, causing Adults material) (dependent on mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute current velocity) levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. **Eel Grass and Other Aquatic Vegetation** Creation/Restoration/Enhancement Construction and **Maintenance Activities**

 Table A-1 (continued).

). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Marine

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of aquatic egetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
void/minimize disturbance of aquatic egetation during project construction.	May affect juvenile survival, growth, and fitness.
arefully evaluate project siting and esign and consider the magnitude of npact mechanisms produced by the roject. Encourage selection of project esigns that minimize effects on ediment supply, longshore drift atterns, and wave energy and current atterns.	May affect juvenile growth and fitness and adult productivity and spawning success.
se non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.

Table A-1	(continued).
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Sub-			Ex	posure						
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.	
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.	

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver	r Dam Removal/M	Iodification							
	Construction and Maintenance Activities								
ļ	Riverine	-			_	_	-	-	
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of all life stages.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom increased flow entrainment asimpoundment dewatering.Possible strandingof alevins in impoundment areas.Adults and juveniles:Mortality, injury, orstress from stranding or entrainment indewatering flows.Juveniles:Increased competition followingdisplacement, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration, resulting indecreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

y			Expe	osure					Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal			impoundments likely to cause scouring flows. Encourage use of beaver deceivers.	
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
-	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
Alter	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
-	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors un Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	decay is most extensive)						
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high	May affect survival at egg, alevin juvenile life-history stages. May spawning productivity.

Table A-2 (continued).HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-			Exp	osure								
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
		Reduced foraging opportunities and rearing habitat availability					Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	quali				
	Aquatic Vegetation modification											
	Riverine											
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	Avoi throu				
							survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.					
	Riparian Vegetation Modification											
	Riverine											
	Altered stream bank and shoreline stability	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities,	Initia meas const impo disco sedin				
		Spawning gravel sedimentation	_				leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.					
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.					
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Repla nativ invas				
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Repla nativ invas				
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	Repla nativ invas				

Minimization Measures ality floodplain habitat.	Resulting Effects of the Submechanism
oid draining impounded area ough use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.
tiate proper erosion control easures both during and after instruction. Replant former poundment with native vegetation to coourage invasives and stabilize diments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
plant former impoundment with tive vegetation to discourage vasives and stabilize sediments.	May affect juvenile rearing.
plant former impoundment with tive vegetation to discourage vasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
plant former impoundment with tive vegetation to discourage vasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.

Sub-			Exp	osure	1	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor		
	Water Quality Modification				-				
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini to ch short back pract proto turbi	
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu envir area. comj	
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limi Repl nativ invas Avoi throu	

Table A-2 (continued).HPA HC

HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)

Construction and Maintenance Activities												
Riverine, Lacustrine, Marine												
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ref con wat wor					

Minimization Measures	Resulting Effects of the Submechanism
Ensure project design avoids and/or ninimizes habitat alterations leading o chronic bank instability. Avoid hort-term turbidity effects above ackground levels to greatest extent racticable. Adhere to established rotocols for managing sediment and irbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
tefuel machinery in a controlled nvironment away from the project rea. Avoid reducing hydraulic omplexity.	May affect survival, growth, and fitness of juveniles and adults.
imit damage to riparian area. Replant former impoundment with ative vegetation to discourage avasives and stabilize sediments. Avoid draining impounded area arough use of beaver deceivers.	May affect alevin development, juvenile survival and productivity as well as adult survival, productivity, and spawning success.
tefuel and service machinery in a controlled environment away from the vater body. Limit heavy machinery vork within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Fatal or predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Sub-			Exp	osure	1	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
							Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.		
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. <u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
							<u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.		

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	roject
	Altered substrate composition		Year round	Permanent	Continuous		competition for suitable habitats, leading to decreased growth, fitness, and survival.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

Table A-2	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-			Expo	osure	-	-			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Coho salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	patterns, and wave energy and current patterns.	
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

b-							
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor
	Lacustrine						
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Coho salmon. This may occur through a number of specific stressors, including
	Altered sediment supply		Year-round	Permanent	Continuous	1	increased exertion and stress due to change in
	Altered substrate composition		Year-round	Permanent	Continuous		current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Coho will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.
	Ecosystem Fragmentation						
	Riverine						
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles;	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.

HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Juveniles; Adults

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
	May affect survival, growth, and fitness of juveniles and adults.

			Exp	osure		-			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. <u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities,	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile life history stages. May affect adult survival and spawning productivity.
	Altered longitudinal habitat connectivity	habitats along longitudinal gradient.					availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. <u>Adults:</u> Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity a juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
Γ	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.

			Exp	osure				
Mecha	nism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Aquatic Modific	e Vegetation cation			-				
Marine								
Altered a producti	autochthonous ion	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Const distur durin
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	
Altered	habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	
Riverin	e and Lacustrine							1
Altered a producti	autochthonous ion	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Const distur during
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.	
Altered	habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and	

Minimization Measures	Resulting Effects of the Submechanism
Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival. May affect adult growth and spawning productivity.
Construction: Avoid/minimize	May offect inverile growth and fitness
disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

			Exp	osure	1	1			Resulting Effects of the
Μ	echanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	parian Vegetation dification								
Riv	verine		1						1
	ered shading, solar input l ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	 <u>Eggs and alevins:</u> Direct mortality due to winter ice formation and scour. <u>Juveniles</u>: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u>: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u>: Decreased spawning fitness due to migration delays caused by thermal barriers. 	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. A affect adult survival and spawnin productivity.
	ered stream bank and reline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. M affect adult survival and spawning productivity.
Alt	ered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning succ and overall population productivi
	ered groundwater– face water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.

Table A-2 (continued).HPA HO

Sub-			Exp	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Marine							
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoi ripar appro- the g
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoi ripar appro the g
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, Coho are known to utilize terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoi ripar appro the g
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Enco perm habit
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoi shore
	Lacustrine						-	
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated habitats may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoi ripar appro the g

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of varian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile growth and survival.
void/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile survival.
void/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile growth and fitness.
courage project designs that limit rmanent alteration of high quality bitat features.	May affect juvenile survival.
void disturbance of vegetation along oreline.	Effects of the action resulting from this impact mechanism are unknown.
void/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to greatest extent possible.	May affect juvenile survival.

HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-			Exp	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoi ripari appro the g
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoi ripari appro the g
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Enco perm habit
	Altered groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coho dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoi the sl
	Water Quality Modification							
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins.Juveniles and adults:Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.Adults:Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu minin to ch short backş pract proto turbio
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensu drast comj

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile survival.
void/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to greatest extent possible.	May affect juvenile growth and fitness.
courage project designs that limit rmanent alteration of high-quality bitat features.	May affect juvenile survival.
void disturbance of vegetation along e shoreline.	Effects of the action resulting from this impact mechanism are unknown.
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
sure project design does not astically reduce hydraulic mplexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Exp	osure					
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival and productivity as well as adult survival, productivity, and spawning success.
pawr	ing Substrate Aug	gmentation							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Fatal or perdation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Hydraulic and Geomorphic M Riverine			Exp	osure			4		
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Us proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	periods when incubating eggs and alevins with limited motility are least	May cause direct mortality or injury egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.		May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modification.		May affect juvenile growth and fitne See effects for related stressors on a life-history stages under Water Qua Modification.
	Hydraulic and Geomorphic Modification		<u> </u>					I	
Geomorphic Modification									
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning succe and overall population productivity
							<u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		

			Exp	oosure			_	
rity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered bank stability (intermediate-term effects from passive augmentation projects) Altered substrate composition/stability	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term Short-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. <u>Juveniles</u> : Altered channel geometry, bank stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	Care desig impa proje augr adve bank to th
	Modification							
	Riverine Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avo proj vege habi
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of gmentation projects that minimize verse effects on channel geometry, nk conditions, and substrate stability the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
oid spawning gravel augmentation ojects in locations where aquatic getation plays a strong role in bitat productivity.	May affect juvenile survival, growth, and fitness.

Sub-								
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification						-	
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini to ch shor back prac proto turbi

HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Construction and Maintenance Activities Riverine Equipment Operation Elevated Hydrocarbons (associated During project Temporary to short-Eggs and alevins; All life-history stages: Physiological Ref Interannual to with potential fuel and oil spills) construction activities term decadal responses to exposure at toxic levels, causing con Juveniles; mortality or injury leading to reduced fitness. wat Adults Bioaccumulation of contaminants at subacute wo levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.

Minimization Measures	Resulting Effects of the Submechanism
inimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and rbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
efuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stress from capture, handling, and relocation.Egg relocation is impractical, likely leading to mortality.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Juveniles:Increased competition once relocated, reduced growth and fitness, and increased predation exposure.Adults:Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub-			Exp	osure		I		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification			-		-		
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u> :Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.Adults:Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini to ch shor back prac proto turbi
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate work

Table A-2 (continued).HPA HCH

HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Riparian Planting/Restoration Enhancement

Construction and Maintenance Activities							
Riverine , Lacustrine, Marine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Mini speci assur speci

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
fuel and service machinery in a ntrolled environment away from the tter body. Limit heavy machinery ork within the channel.	May affect survival, growth, and fitness of juveniles and adults.
inimize disturbance during invasive eccies removal. Use measures to sure rapid establishment of planted eccies.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-2	(continued).
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Sub-			Exp	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Minin specie erosio after c
				recovery)			<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality	
		Spawning gravel sedimentation – due to removal of invasive riparian species	•				caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	
							Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	
	Aquatic Vegetation Modification							
	Riverine, Lacustrine, Marine					V		
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Desig canop contin

Minimization Measures	Resulting Effects of the Submechanism
nimize disturbance during invasive eccies removal. Use appropriate osion control BMPs both during and er construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
sign riparian patches with variable hopy coverage so that sunlight will ntinue to reach the channel.	May affect juvenile growth and fitness

Sub-	-		Exp	osure	-								
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism				
	Riparian Vegetation Modification												
	Riverine, Lacustrine, Marine												
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness				
	Water Quality Modification												
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.				
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.				

			Exp	osure				Demiking Fifthered					
Mechanism	of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism				
and Creation	on Restor	ration/Enhancement											
	Construction and Maintenance Activities												
Riverine and	Riverine and Marine												
Equipment O	peration	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>Juveniles, adults</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.				
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noi disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pi driving) may lead to direct mortal injury limiting to survival.				

-			Exp	osure					
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality juveniles and adults. Stress may aff survival, growth and fitness, and ad spawning productivity.
						<u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.			
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injur juvenile life-history stage. Injury a stress may affect survival, growth, fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles;	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May af adult fitness and spawning
						ency) Adults	<u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.		productivity.
							<u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.		
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Sub-			Exp	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini: to ch short back pract proto turbi
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate work

Beach Nourishment/Contouring

Construction and Maintenance Activities							
Marine and Lacustrine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>Juveniles, adults</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contro water machi projec
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid produ comm

Minimization Measures	Resulting Effects of the Submechanism
Insure project design avoids and/or ninimizes habitat alterations leading o chronic bank instability. Avoid hort-term turbidity effects above ackground levels to greatest extent racticable. Adhere to established rotocols for managing sediment and urbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
tefuel and service machinery in a ontrolled environment away from the vater body. Limit heavy machinery vork within the channel.	May affect survival, growth, and fitness of juveniles and adults.
tefuel and service machinery in a controlled environment away from the vater body. Limit heavy hachinery/vessel work within the roject area.	May affect survival, growth, and fitness of juveniles and adults.
void project sites which are roductive and have a healthy benthic ommunity.	May affect growth and fitness at juvenile life-history stage.

,			Exp	osure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification		-	÷	-		•	•	-
	Marine and Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification						·		
	Marine and Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover					survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.		
	Water Quality Modification								
	Marine and Lacustrine								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating and alevins. May affect juvenile growth and fitness and adult productivity and spawning success
_	Altered Pollutant Loading	Elevated Hydrocarbons (associated	During project	Temporary to short-	Interannual to	Juveniles;	habitat (due to substrate embeddedness) and reduced spawning success. Juveniles and adults: Physiological responses	Refuel and service machinery in a	May affect survival, growth, and
		with potential fuel and oil spills)	construction activities	term (dependent on contributing mechanism of impact)	decadal	Adults	to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	controlled environment away from the water body.	fitness of juveniles and adults.

-			Exp	osure				
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
ef C	Creation/Restoratio	n/Enhancement						
	Construction and Maintenance Activities							
	Marine and Lacustrine							
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoi perio prese
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoi noise equij techr
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoi prod com

Minimization Measures	Resulting Effects of the Submechanism
roid construction activities during riods when individuals may be esent, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
void/minimize cavitation to limit ise intensity. Promote use of vessels uipped with antinoise/antivibration chnology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
oid project sites which are oductive and have a healthy benthic mmunity.	May affect growth and fitness at juvenile life-history stage.

		Exp	osure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Hydraulic and Geomorphic Modification		-	-	-	-			
Marine								
Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival and producti juvenile life-history stage. Decre fitness may affect survival and productivity during ocean migrat life-history phase. May affect adult growth and fitm
Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Coho salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction	patterns, and wave energy and current patterns.	and spawning productivity.
Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity,		
Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		decreased fitness for marine migration, and direct mortality. <u>Adults</u> : Adult Coho salmon forage in nearshore environments during return		
Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		migrations. Alteration of nearshore habitat characteristics through these sub-mechanisms may lead to decreased food web productivity and prey availability. This may lead to decreased growth and decrease spawning fitness.		

			Expo	osure				
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Lacustrine	-						
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Care desi impa proj desi sedi
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Coho salmon. This may occur through a number of specific stressors, including	patte patte
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web	
	Altered sediment supply		Year-round	Permanent	Continuous		alterations and decreased foraging opportunity, and increased competition for	
	Altered substrate composition		Year-round	Permanent	Continuous		suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Coho will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.	
	Ecosystem Fragmentation							
-	Marine Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoi prox corri pred
	Lacustrine							1
-	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoi prox corri pred
	Aquatic Vegetation Modification							
ſ	Marine							
-	Altered cover and habitat		Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avo vege
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on liment supply, longshore drift tterns, and wave energy and current tterns.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
roid placement of reef projects in poximity to juvenile migratory rridors, such that increased edation exposure may occur.	May affect juvenile survival, growth and fitness.
roid placement of reef projects in oximity to juvenile migratory rridors, such that increased edation exposure may occur.	May affect juvenile survival, growth and fitness.
void/minimize disturbance of aquatic getation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.

			Exp	oosure	-	-			
/	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous production Altered cover and habitat	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growt and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating and alevins. May affect juvenile growth and fitness and adult productivity and spawning success
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
	ass and Other Aqu on/Restoration/En Construction and Maintenance Activities								
	Marine Planting activities and	Visual, physical, and noise related	During project	Tomporogy	Interannual to	Iuvanilas	Juveniles: Stress and behavioral avoidance by	Adhere to system-specific in-water	May cause temporary behavioral
	vessel use	disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>suvennes</u> : stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	work windows.	avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Maintenance Activities Marine							
Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhe work
Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoi above exten estab sedin

Sub-			Ex	posure		_			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver	: Dam Removal/M	odification							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of alevins in impoundment areas. <u>Adults and juveniles</u> : Mortality, injury, or stress from stranding or entrainment in dewatering flows. <u>Juveniles</u> : Increased competition following displacement, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

-			Ex	posure					
rity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification		-		-	-	-	-	-
	Riverine		-			-			
	Altered channel geometry	suitability, reduced food web long-term Juveni	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring	May affect survival at egg, alevin, an juvenile life-history stages. May affe spawning productivity.			
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		<u>suvenines</u> . Thered enables geometry, now	flows. Encourage use of beaver deceivers.	
	Altered bank stability]	Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
ļ	Riverine		1		F	- 1			.
	Altered hyporheic flow/exchange	ic Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	growth and decay is most extensive)						
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-3	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

		Ex	posure									
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor						
Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chum dependence on autochthonous inputs from aquatic vegetation is limited, as this species does not forage in riverine and lacustrine environments. Therefore, effects on juvenile chum growth and fitness will be limited.	Requ hydr befo desig of hi					
	Reduced refuge habitat availability	Year-round	Permanent	Continuous	Adults	<u>Adults</u> : This stressor may limit the availability of adult spawning habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density- dependent effects on adult spawning success.	Requ hydr befo desig of hi					
Aquatic Vegetation Modification												
Riverine												
Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat, increased predation exposure. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory habitat.	Enco perm habit					
Riparian Vegetation Modification	Riparian Vegetation											
Riverine												
Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation successdue to decreased redd dissolved oxygen asdescribed for related stressor responses underWater Quality Modification.Juveniles:Decreased refuge habitatavailability and foraging opportunities,leading to increased competition and resultingeffects on growth and fitness.Potentialhabitat avoidance and/or injury and mortalitycaused by excessive turbidity as described forrelated stressor responses under Water QualityModification.Adults:Decreased spawning success due todecreased availability of suitable spawninghabitat.Potential migration delay, habitat	Initia meas const impo disco sedin					

Minimization Measures	Resulting Effects of the Submechanism
equire assessment of the draulic effects of the project fore permitting; avoid permitting signs that lead to disconnection high quality floodplain habitat.	Impact mechanism is unlikely to affect chum salmon.
equire assessment of the draulic effects of the project fore permitting; avoid permitting signs that lead to disconnection high quality floodplain habitat.	May affect spawning productivity.
courage project designs that limit rmanent alteration of high-quality bitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.
tiate proper erosion control easures both during and after nstruction. Replant former poundment with native vegetation to acourage invasives and stabilize liments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

			Ex	posure					
r	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	<u>Juveniles</u> : Limited effects from food web alteration due to minimal dependence on freshwater forage resources.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	Unlikely to affect juvenile rearing.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival productivity, and spawning success.

			Ex	kposure	1	- I		
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
m	Woody Debris ent/Movement/Re nstruction impact	emoval (for placement as apply)						
	Construction and Maintenance Activities							
Ē	Riverine, Marine							
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Re co wa wo
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	A ^v im No ha dr Us rea coo Er an Li ma

Table A-3 (continued).HPA HCP Habitat M

HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Minimization Measures

Resulting Effects of the Submechanism

efuel and service machinery in a ontrolled environment away from the ater body. Limit heavy machinery ork within the project area.

void pile-driving noise in excess of mpact thresholds established by IOAA Fisheries and USFWS in abitats used by species. Limit pile riving to in-water work windows. (se double-confined bubble curtain to educe sound pressure, or work within onfined or dewatered work areas. ncourage use of vibratory hammers and wooden pilings where practicable. imit in-water use of heavy machinery. May affect survival, growth, and fitness of juveniles and adults.

May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Sub-			Ex	posure			_		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition		Year round	Permanent	Continuous		decreased growth, fitness, and survival. Adults: Changes in channel morphology may		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

Table A-3 ((continued).
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ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor				
$\overline{}$	Marine										
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile chum salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Car des imp pro des sed			
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent			pat pat			
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous						
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave	Permanent	Continuous						
			and/or current regime, routine grounding, anchor trenching])								
	Lacustrine										
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	N/A	<u>N/A</u>	<u>N/4</u>			
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common						
Γ	Altered sediment supply		Year-round	Permanent	Continuous						
	Altered substrate composition		Year-round	Permanent	Continuous						
	Ecosystem Fragmentation										

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of mpact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. However, this impact pathway has not been well studied.
<u>N/A</u>	<u>N/A</u>

Sub-			Ex	posure	· ·	- r						
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification	Requ hydra befor				
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.					
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced refuge habitat availability	Year-round	Permanent	Continuous	Adults	Adults: This stressor may limit the availability of adult spawning habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density- dependent effects on adult spawning success.	Requ hydra befor desig of hig				
	Altered longitudinal habitat connectivity											
	Marine											
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : LWD removal in the marine environment may fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid projec cumul preval				
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encou perma habita				
	Lacustrine											
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>				
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>				

Minimization Measures	Resulting Effects of the Submechanism
Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
	May affect survival, growth, and fitness of juveniles and adults.
Require assessment of the hydraulic effects of the project before permitting; avoid permitting lesigns that lead to disconnection of high quality floodplain habitat.	May affect spawning productivity.
Avoid permitting LWD removal projects in areas where significant numulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. However, this impact pathway has not been well studied.
Encourage project designs that limit permanent alteration of high-quality pabitat features.	May affect juvenile survival. However, this impact pathway has not been well studied.
<u>N/A</u>	<u>N/A</u>
<u>J/A</u>	<u>N/A</u>

Sub-			Ex	kposure	T	-								
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor							
	Aquatic Vegetation Modification							-						
	Marine													
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	<u>Const</u> distur during						
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.							
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due							
	Riverine		to decreased food web productivity.											
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Const distur during						
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.							
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability, potentially leading to altered migratory behavior and increased predation exposure.							

Minimization Measures	Resulting Effects of the Submechanism
Construction: Avoid/minimize listurbance of aquatic vegetation luring project construction.	May affect juvenile growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival. May affect adult growth and spawning productivity.
Construction: Avoid/minimize listurbance of aquatic vegetation luring project construction.	Impact mechanism is unlikely to affect chum salmon.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival.

		E							
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification		-	-	•	-		-	-
	Riverine								
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Potential delays in migration or alterations in migration behavior.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival an spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high- flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubationsuccess due to decreased redd dissolvedoxygen as described for related stressorresponses under Water QualityModification.Juveniles:Potential delays in migrationor alteration in migration behavior,increased predation exposure.Adults:Decreased spawning success due todecreased availability of suitable spawninghabitat.Potential migration delay, habitatavoidance, and/or injury and mortality causedby excessive turbidity, as described for relatedstressor responses under Water QualityModification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat, increased predation exposure. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen; reduced thermal refuge	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles: Decreased availability of thermal refuge habitat, resulting in increased thermal stress and increased competition for suitable habitats. <u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid permitting of projects in areas with springs, seeps, or other sources of significant groundwater recharge. Limit alteration of riparian vegetation to greatest extent practicable.	May affect survival of eggs and alevins. May affect juvenile survival and growth. May affect adult spawning productivity.

			Ex	posure					
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and growth. However, this impact pathway has not been well studied.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. However, this impact pathway has not been well studied.
-	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chum dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, chum are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness. However, this impact pathway has not been well studied.
-	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high quality habitat features.	May affect juvenile survival. However, this impact pathway has not been well studied.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Chum dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown. However, this impact pathway has not been well studied.

		Ex	posure	1	· · · · · · · · · · · · · · · · · · ·			Resulting Effects of th
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Lacustrine			-					
Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>
Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	<u>N/A</u>	V/A	<u>N/A</u>	<u>N/A</u>
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous		<u>V/A</u>	<u>N/A</u>	<u>N/A</u>
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	N/A 1	<u>V/A</u>	<u>N/A</u>	<u>N/A</u>
Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous		<u>J/A</u>	<u>N/A</u>	<u>N/A</u>

Sub-			Ex	posure		i			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification					-			
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adul survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

•.			Ex	posure	-	-			
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
awn	ing Substrate Aug	mentation							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noiss disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pild driving) may lead to direct mortali injury limiting to survival.

			Ex	posure	1	r			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenil chum salmon.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitn See effects for related stressors on a life-history stages under Water Qua Modification.
Hydraulic and Geomorphic Modifica									
ļ	Riverine		1	Τ	1	1	1	I	I
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning succ and overall population productivit
							availability of suitable migratory and spawning habitat.		

-]	Exposure	7			
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin	Caret desig impa proje desig
	Altered substrate composition/stability			Short-term to long- term			survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, substrate composition, and groundwater inputs can result in decreased refuge habitat suitability, potentially leading to changes in migratory behavior, increased stress, and increased predation exposure. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	chani subst groui exter
	Aquatic Vegetation Modification							
	Riverine							
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Chum dependence on autochthonous inputs from aquatic vegetation is limited, as this species does not forage in riverine and lacustrine environments. Therefore, effects on juvenile chum growth and fitness will be limited.	Avoi proje vege habit
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity,	Year-round	Short-term to permanent	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability, potentially leading to altered	

(dependent on nature

of activity)

Table A-3 (continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

migratory behavior and increased predation

exposure.

reduction in available cover

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on annel geometry, flow velocity, ostrate composition, and oundwater exchange to the greatest ent practicable.	May affect survival at egg and alevin, and juvenile life-history stages. May affect spawning productivity.
oid spawning gravel augmentation ojects in locations where aquatic getation plays a strong role in oitat productivity.	May affect juvenile survival, growth, and fitness.
	May affect juvenile survival.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification	-	-	-	-	-		
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini to ch short back pract proto turbi
In-Cha	annel/Off-Channel	Habitat Creation/Modific	ation					
	Construction and Maintenance Activities							
	Riverine							
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr water work

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
fuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Fatal or predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub-			Ex	posure			_	
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification		-	-	-	-		_
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini to cl shor back prac prote turb
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu cont wate worl

HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Riparian Planting/Restoration Enhancement

Riverine Marine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due towinter ice formation and scour.Juveniles:Altered growth and survivalcaused by temperatures outside optimalgrowth range and alteration of food webpatterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration delays caused by thermal barriers.	Mir spe assi spe

Minimization Measures	Resulting Effects of the Submechanism
Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Mini spec erosi after
	Aquatic Vegetation Modification							
	Riverine, Marine							
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Desi cano conti

Minimization Measures	Resulting Effects of the Submechanism
nimize disturbance during invasive eccies removal. Use appropriate osion control BMPs both during and er construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
sign riparian patches with variable hopy coverage so that sunlight will ntinue to reach the channel.	May affect juvenile growth and fitness in marine environments.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification	-	•	•	-	-	-	•	•
	Riverine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

)-			Ex	posure	1							
vity oe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
etlai	nd Creation Restor	ation/Enhancement										
	Construction and Maintenance Activities											
	Riverine and Marine											
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.			
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortalit injury limiting to survival.			

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.

Sub-			Ex	posure	.	.		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification		-		-	-	-	
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensur minin to chr short- backg practi proto turbic
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contro water work

HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Beach Nourishment/Contouring

Marine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contre water mach projec
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoi are p benth
Riverine				frequency)			

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
fuel and service machinery in a ntrolled environment away from the tter body. Limit heavy machinery ork within the channel.	May affect survival, growth, and fitness of juveniles and adults.
fuel and service machinery in a ntrolled environment away from the tter body. Limit heavy achinery/vessel work within the oject area.	May affect survival, growth, and fitness of juveniles and adults.
void locating projects in areas which e productive and have a healthy nthic community.	May affect growth and fitness at juvenile life-history stage.

			Ex	kposure	· · · · · · · · · · · · · · · · · · ·	7	-			
Mech	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
Equipme	nent Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, ar fitness of juveniles and adults.	
Bank, ch disturbar	hannel, shoreline ance	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid locating projects in areas which are productive and have a healthy benthic community.	May affect growth and fitness a juvenile life-history stage.	
Hydraul Geomor	ulic and orphic Modification									
Marine	<u>)</u>					•				
Altered s	sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid locating projects in areas which are productive and have a healthy benthic community.	May affect growth and fitness a juvenile life-history stage.	
Riverine	ne	1					l	1		
Altered	sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid locating projects in areas which are productive and have a healthy benthic community.	ich May affect growth and fitness juvenile life-history stage.	
Aquatic Modifica	c Vegetation cation						·			
Marine	9									
Altered a production	autochthonous ion	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. Maffect adult growth and spawnin productivity.	
Altered of	cover and habitat	Reduced cover					survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	productive, vegetated aquate monat.		
Riverine	ne									
Altered a production	autochthonous ion	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect growth and fitness a juvenile life-history stage.	
							survival, growni, and finless.	productive, vegetated aquatic nabitat.		

Table A-3	(continued).
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Sub-			Ex	posure			_		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.
Reef C	reation/Restoration	n/Enhancement							
	Construction and Maintenance Activities								
1	Marine								
, i	Equipment operation and	Elevated noise visual and physical	During project	Temporary (auditory	Interannual to	Iuveniles.	All life-history stages: Stressor response	Avoid construction activities during	May affect survival at all life-history

Marine								
Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages:Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from:• Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey• Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avo perio pres	
onstruction vessel eration	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avo nois equi tech	

Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
Avoid/minimize cavitation to limit	May affect survival, growth, and
noise intensity. Promote use of vessels	fitness due to avoidance behavior,
equipped with antinoise/antivibration	decreased foraging success, and
technology where practicable.	increased predation risk.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid produ comm
	Lacustrine	·						
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid perio prese
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoie noise equip techn
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoi produ comm

Minimization Measures	Resulting Effects of the Submechanism
void project site which are oductive and have a healthy benthic mmunity.	May affect growth and fitness at juvenile life-history stage.
oid construction activities during riods when individuals may be esent, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
void/minimize cavitation to limit ise intensity. Promote use of vessels uipped with antinoise/antivibration chnology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
void project site which are oductive and have a healthy benthic mmunity.	Exposure will be minimal because chum salmon do not rear in lakes. Consequently, effects are negligible.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification						-		
	Marine	-							
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Chum salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. <u>Adults</u> : Adult Chum salmon forage in nearshore environments during return	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and fitness,
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				and spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		migrations. Alteration of nearshore habitat characteristics through these sub-mechanisms may lead to decreased food web productivity and prey availability. This may lead to decreased growth and decrease spawning fitness.		

Table A-3	(continued).
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Sub-			Exj	posure	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Lacustrine							
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Caref desig impac proje desig sedin
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of migratory habitat for adult chum salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave	patter patter
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, and increased competition for suitable habitats. The combined effect of	
	Altered sediment supply		Year-round	Permanent	Continuous		these stressors can result in decreased growth	
	Altered substrate composition		Year-round	Permanent	Continuous		and productivity, decreased fitness for marine migration, and direct mortality. Adult chum will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.	
	Ecosystem Fragmentation				· · · · · · · · · · · · · · · · · · ·			
	Marine							
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoie proxi corric preda
	Lacustrine	•			1			
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid proxi corric preda
	Aquatic Vegetation Modification							
	Marine							
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoi veget
	Lacustrine						<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	e

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and esign and consider the magnitude of npact mechanisms produced by the roject. Encourage selection of project esigns that minimize effects on ediment supply, longshore drift atterns, and wave energy and current atterns.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
void placement of reef projects in roximity to juvenile migratory orridors, such that increased redation exposure may occur.	May affect juvenile survival, growth and fitness.
avoid placement of reef projects in roximity to juvenile migratory orridors, such that increased redation exposure may occur.	May affect juvenile survival, growth and fitness.
void/minimize disturbance of aquatic egetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.

Sub-			Ex	posure		-		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered cover and habitat	Reduced cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid vegeta
	Water Quality Modification							
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefu desigr impac projec desigr sedim pattern pattern
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use n

HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement

	Construction and Maintenance Activities							
Ī	Marine							
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adh
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avo abov exte estal sedi

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Resulting Effects of the Submechanism
Impact mechanism is unlikely to affect chum salmon as they do not rear in lakes.
May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
May affect survival, growth, and fitness of juveniles and adults.
May cause temporary behavioral avoidance and displacement.
May cause temporary behavioral avoidance and displacement.

Sub-			Ex	posure									
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism				
Beaver	r Dam Removal/Mo	odification											
	Construction and Maintenance Activities												
	Riverine												
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.				
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.				
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of alevins in impoundment areas. <u>Adults and juveniles</u> : Mortality, injury, or stress from stranding or entrainment in dewatering flows. <u>Juveniles</u> : Increased competition following displacement, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.				
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.				
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.				

			Ex	posure					
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification				-				
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring	May affect survival at egg, alevin, an juvenile life-history stages. May aff spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase	flows. Encourage use of beaver deceivers.	
	Altered bank stability]	Year round especially during high flows	Intermediate-term to long-term	Seasonal		competition for suitable habitats, leading to decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased		
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous		survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
_	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine		1		1				1
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification		See effects for related stressors under Water Quality Modification
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	growth and decay is most extensive)						
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

			Ex	posure								
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pink dependence on autochthonous inputs from aquatic vegetation is limited, as this species does not forage in riverine and lacustrine environments. Therefore, effects on juvenile pink growth and fitness will be limited.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	Impact mechanism is unlikely to affect pink salmon.			
		Reduced refuge habitat availability	Year-round	Permanent	Continuous	Adults	<u>Adults</u> : This stressor may limit the availability of adult spawning habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density- dependent effects on adult spawning success.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect spawning productivity.			
	Aquatic Vegetation Modification											
-	Riverine		1									
	Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat, increased predation exposure. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.			
	Riparian Vegetation Modification											
	Riverine											
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.			

		Ex	posure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	<u>Juveniles</u> : Limited effects from food web alteration due to minimal dependence on freshwater forage resources.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	Unlikely to affect juvenile rearing.
Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification
	Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification
Water Quality Modification								
Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

			Ex	xposure	r	- i		
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
em	Woody Debris ent/Movement/Re nstruction impact	emoval (for placement s apply)						
	Construction and Maintenance Activities							
- [Riverine, Marine							
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	

Minimization Measures

Resulting Effects of the Submechanism

efuel and service machinery in a ontrolled environment away from the ater body. Limit heavy machinery ork within the project area.

void pile-driving noise in excess of mpact thresholds established by IOAA Fisheries and USFWS in abitats used by species. Limit pile riving to in-water work windows. (se double-confined bubble curtain to educe sound pressure, or work within onfined or dewatered work areas. ncourage use of vibratory hammers and wooden pilings where practicable. imit in-water use of heavy machinery. May affect survival, growth, and fitness of juveniles and adults.

May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Sub-		Exposure					_		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification			·		·			
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition		Year round	Permanent	Continuous		decreased growth, fitness, and survival. Adults: Changes in channel morphology may		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival and productivity a juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. However, this impact pathway has not been well
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile pink salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.		studied.
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine	1				1	1	1	1
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

Sub-				Exposure			_	
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced refuge habitat availability	Year-round	Permanent	Continuous	Adults	Adults: This stressor may limit the availability of adult spawning habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density- dependent effects on adult spawning success.	Requ hydra befor desig of hig
	Altered longitudinal habitat connectivity							
	Marine		•					
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : LWD removal in the marine environment may fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoic projec cumu preva
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encou perma habita
	Lacustrine							
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requi footpr object in area effect
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encou perma habita

Minimization Measures	Resulting Effects of the Submechanism
Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect spawning productivity.
Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. However, this impact pathway has not been well studied.
Encourage project designs that limit permanent alteration of high-quality nabitat features.	May affect juvenile survival. However, this impact pathway has not been well studied.
Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity. However, pink salmon do not rear in lakes so the impact will not be acute.
Encourage project designs that limit permanent alteration of high-quality nabitat features.	May affect juvenile survival. However, pink salmon do not rear in lakes so the impact will not be acute.

Sub-			Ex	posure	1	Ţ.		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Aquatic Vegetation Modification							
	Marine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Const distur during
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	
	Riverine and Lacustrine		1	I			1	
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Const distur during
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability, potentially leading to altered migratory behavior and increased predation exposure.	

Minimization Measures	Resulting Effects of the Submechanism
<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival. May affect adult growth and spawning productivity.
Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	Impact mechanism is unlikely to affect pink salmon.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival.

Sub-			Ex	posure					
ictivity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification		-	-			-	-	-
	Riverine								
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Potential delays in migration or alterations in migration behavior. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high- flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Potential delays in migration or alteration in migration behavior, increased predation exposure. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat, increased predation exposure. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen; reduced thermal refuge	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles: Decreased availability of thermal refuge habitat, resulting in increased thermal stress and increased competition for suitable habitats. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid permitting of projects in areas with springs, seeps, or other sources of significant groundwater recharge. Limit alteration of riparian vegetation to greatest extent practicable.	May affect survival of eggs and alevins. May affect juvenile survival and growth. May affect adult spawning productivity.

		Exposure							
У	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine		-	-			-		
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and growth. However, this impact pathway has not been well studied.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. However, this impact pathway has not been well studied.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pink dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, pink are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness. However, this impact pathway has not been well studied.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high quality habitat features.	May affect juvenile survival. However, this impact pathway has not been well studied.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pink dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown. However, this impact pathway has not been well studied.

			Ex	posure					
r ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. However, pink salmon do not rear in lakes so the impact will not be acute.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. However, pink salmon do not rear in lakes so the impact will not be acute.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Alteration of vegetation will result in decreased foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness However, pink salmon do not rear in lakes so the impact will not be acute.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival. However, pink salmon do not rear in lakes so the impact will not be acute.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pink dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along the shoreline.	Effects of the action resulting from this impact mechanism are unknown.

Sub-			Ex	posure	-	-			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification	-	-	-	-	-		-	
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

b-			Ex	posure	r	r			
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
pawr	ning Substrate Aug	mentation							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortalit injury limiting to survival.

		Ex	posure	1				
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
						Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
						<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
	Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
	Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvening pink salmon.
	Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitm See effects for related stressors on a life-history stages under Water Qua Modification.
Hydraulic and Geomorphic Modification								
Riverine Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning succe and overall population productivity
						<u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		

HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Table A-4 (continued).

b-			E	xposure				
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin	Car desi imp proj desi
	Altered substrate composition/stability			Short-term to long- term			survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, substrate composition, and groundwater inputs can result in decreased refuge habitat suitability, potentially leading to changes in migratory behavior, increased stress, and increased predation exposure. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	char subs grou exte
	Aquatic Vegetation Modification							
	Riverine		1			Γ	1	1
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Pink dependence on autochthonous inputs from aquatic vegetation is limited, as this species does not forage in riverine and lacustrine environments. Therefore, effects on juvenile pink growth and fitness will be limited.	Avo proj vege habi
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity,	Year-round	Short-term to permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability, potentially leading to altered	

(dependent on nature

of activity)

Table A-4 (continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

migratory behavior and increased predation

exposure.

reduction in available cover

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on annel geometry, flow velocity, ostrate composition, and oundwater exchange to the greatest ent practicable.	May affect survival at egg and alevin, and juvenile life-history stages. May affect spawning productivity.
oid spawning gravel augmentation ojects in locations where aquatic getation plays a strong role in oitat productivity.	May affect juvenile survival, growth, and fitness.
	May affect juvenile survival.

b-			Ex	posure	-	-						
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	Water Quality Modification											
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu minit to ch short back, pract proto turbi				
-Cha	annel/Off-Channel	Habitat Creation/Modific	cation									
	Construction and Maintenance Activities											
	Riverine											
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or	Refu contr wate work				

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
fuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Ex	posure	·				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-			Ex	posure	-				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub-			Ex	posure		,		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification		-	-	-	-	-	-
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini to ch short back pract proto turbi
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate work

Riparian Planting/Restoration Enhancement

Riverine , Lacustrine, Marine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Min spe assi spe

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
fuel and service machinery in a ntrolled environment away from the tter body. Limit heavy machinery ork within the channel.	May affect survival, growth, and fitness of juveniles and adults.
nimize disturbance during invasive eccies removal. Use measures to sure rapid establishment of planted eccies.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

b-			Ex	posure		.		
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Mini spec erosi after
	Aquatic Vegetation Modification							
	Riverine, Lacustrine, Marine							
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Desig canop contin

Minimization Measures	Resulting Effects of the Submechanism
nimize disturbance during invasive ecies removal. Use appropriate ssion control BMPs both during and er construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
sign riparian patches with variable hopy coverage so that sunlight will ntinue to reach the channel.	May affect juvenile growth and fitness in marine environments.

Sub-Exposure activity **Mechanism of Impact** Stressor When Duration Frequency Life-history Form **Response to Stressor** Туре **Riparian Vegetation** Modification Riverine, Lacustrine, Marine Altered Shading and solar Decreased productivity (locally Year-round (most Permanent Continuous Juveniles <u>Juveniles</u>: Reduced foraging De pronounced in spring due to increased shading) opportunities due to decreased food web vai input and summer when productivity and decreased growth and sur cha vegetation growth is fitness. most extensive) Water Quality Modification Eggs and alevins: Direct mortality due to Μ Expansion of thermal regime - due to Short-term to Eggs and alevins; Altered Temperatures Year-round Seasonal removal of invasive riparian species (pronounced in intermediate winter ice formation and scour. spe Juveniles; winter/summer during (i.e., increased summer temperatures, (dependent on nature ass Juveniles: Altered growth and survival Adults decreased winter temperatures) solar radiation and of riparian impacts). spe caused by temperatures outside optimal ambient temperature growth range and alteration of food web extremes) patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers. Dependent on Eggs and alevins: Turbidity sufficient to Ens Increased suspended solids - due to Short-term to Intermittent to Altered suspended solids Eggs and alevins; removal of invasive riparian species contributing cause fine sediment embeddedness may lead intermediate interannual-decadal mi Juveniles; mechanism of impact (dependent on (dependent on to direct mortality and decreased survival of to Adults contributing contributing eggs and alevins. sho mechanism of mechanism of bac Juveniles and adults: Responses vary impact) pra impact) depending on stressor magnitude. pro Unavoidable extreme turbidity may cause turl physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.

Minimization Measures	Resulting Effects of the Submechanism
esign riparian patches with ariable canopy coverage so that inlight will continue to reach the nannel.	May affect juvenile growth and fitness
linimize disturbance during invasive becies removal. Use measures to ssure rapid establishment of planted becies.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
nsure project design avoids and/or inimizes habitat alterations leading ochronic bank instability. Avoid nort-term turbidity effects above ackground levels to greatest extent racticable. Adhere to established rotocols for managing sediment and rbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

)- vity			Exj	posure	1	<u></u>			
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
tla	nd Creation Restor	ation/Enhancement							
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noiss disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pil driving) may lead to direct mortali injury limiting to survival.

Sub-			Ex	posure	_				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Modification. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.

Sub-			Ex	posure	<u>,</u>			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification			-		-	-	-
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensur minim to chru- short- backg practic protoc turbid
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contro water work

Beach Nourishment/Contouring

Construction and Maintenance Activities							
Marine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contro water mach proje
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid produ comm
Lacustrine						•	•

Minimization Measures	Resulting Effects of the Submechanism
Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

			Ex	posure	-							
Me	echanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
Equip	pment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	Exposure will be minimal becau pink salmon do not rear in lakes Consequently, effects are neglig			
	<, channel, shoreline Irbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	Exposure will be minimal becau pink salmon do not rear in lakes Consequently, effects are neglig			
	Hydraulic and Geomorphic Modification											
Mari	ine											
Altere	red sediment supply	Localized alteration in invertebrate abundance from burial.	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness a juvenile life-history stage.			
Lacu	ustrine	l					1	1				
Altere	red sediment supply	Localized alteration in invertebrate abundance from burial.	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	Exposure will be minimal becau pink salmon do not rear in lakes Consequently, effects are neglig			
	atic Vegetation lification											
Mari	ine											
produ	red autochthonous uction	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. Maffect adult growth and spawnin productivity.			
Altere	red cover and habitat	Reduced cover					survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.					
Lacu	ustrine	•						1	I			
H	red autochthonous	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability, leading to increased competition and predation exposure, resulting in decreased	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of	Exposure will be minimal becau pink salmon do not rear in lakes Consequently, effects are neglig			
Altere	uction			nature of activity)			survival, growth, and fitness.	productive, vegetated aquatic habitat.	Consequently, effects are neglig			

Sub-		Exposure							
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.
Reef C	reation/Restoration	n/Enhancement							
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and	Elevated noise, visual and physical	During project	Temporary (auditory	Interannual to	Iuveniles:	All life-history stages: Stressor response	Avoid construction activities during	May affect survival at all life-history

Marine								
Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoia perio prese	
onstruction vessel eration	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoie noise equip techn	

void construction activities during riods when individuals may be esent, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
void/minimize cavitation to limit	May affect survival, growth, and
ise intensity. Promote use of vessels	fitness due to avoidance behavior,
uipped with antinoise/antivibration	decreased foraging success, and
chnology where practicable.	increased predation risk.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor When Du		Duration	Duration Frequency Life-history Form		Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	disturbance abundance from burial, increased construction and decadal (depending of		<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success.				
	Lacustrine						•	•	
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	Exposure will be minimal because pink salmon do not rear in lakes. Consequently, effects are negligible.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	Exposure will be minimal because pink salmon do not rear in lakes. Consequently, effects are negligible.

Sub-			Ex	posure		_			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification		-	-	-	-	-	-	-
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Pink salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. <u>Adults</u> : Adult Pink salmon forage in nearshore environments during return migrations. Alteration of nearshore habitat characteristics through these sub-mechanisms may lead to decreased food web productivity and prey availability. This may lead to decreased growth and decrease spawning fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and fitness, and spawning productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

			Exj	posure	1						
y Mechanism o	of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor				
Lacustrine	Lacustrine										
Altered wave en period waves)	ergy (short-	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Care desig impa proje desig sedin			
Altered current	velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of migratory habitat for adult pink salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave	patte patte			
Altered nearshot circulation patte			Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, and increased competition for suitable habitats. The combined effect of				
Altered sedimen	t supply		Year-round	Permanent	Continuous		these stressors can result in decreased growth				
Altered substrate composition	2		Year-round	Permanent	Continuous		and productivity, decreased fitness for marine migration, and direct mortality. Adult pink will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.				
Ecosystem Frag	Ecosystem Fragmentation										
Marine	-										
Altered cover an	nd habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoi prox corri preda			
Lacustrine								1-			
Altered cover an	ıd habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoi proxi corri preda			
Aquatic Vegeta Modification	tion										
Marine			r	1	•			.			
	nd habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature	Continuous	Juveniles; Adults	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and	Avoi vege			

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and current tterns.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
void placement of reef projects in oximity to juvenile migratory rridors, such that increased edation exposure may occur.	May affect juvenile survival, growth and fitness.
yoid placement of reef projects in oximity to juvenile migratory rridors, such that increased edation exposure may occur.	May affect juvenile survival, growth and fitness.
void/minimize disturbance of aquatic getation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.

y	-	Exposure							Resulting Effects of the			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
	Altered cover and habitat	Reduced cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	Impact mechanism is unlikely to affe pink salmon as they do not rear in lakes.			
	Water Quality Modification											
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.			
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.			
Gra atio	ass and Other Aqu on/Restoration/Enl Construction and Maintenance Activities Marine	atic Vegetation nancement										
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.			
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.			

Construction and Maintenance Activities							
Marine							
Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adh worl
Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avo abov exte estal sedi

Sub-			Exp	osure	1							
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
Beaver	r Dam Removal/M	Iodification										
	Construction and Maintenance Activities											
]	Riverine											
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of all life stages.			
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.			
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom increased flow entrainment asimpoundment dewatering.Possible strandingof alevins in impoundment areas.Adults and juveniles:Mortality, injury, orstress from stranding or entrainment indewatering flows.Juveniles:Increased competition followingdisplacement, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration, resulting indecreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.			
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.			
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.			

b-			Exp	osure	-	-		
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Hydraulic and Geomorphic Modification		-				-	
	Riverine	-					-	
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Care desig impa proje desig
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased refuge habitat during migration to lacustrine rearing environments, and increased predation exposure. Juvenile river	chan subst grou exter
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal		rearing sockeye may also experience decreased foraging opportunity, leading to increased competition and decreased growth	ig to
Altered substrate composition (includ spawning gravel sedimentation)	composition (including spawning gravel		Year round	Intermediate-term to long-term	Continuous		and fitness. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading	
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous		to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	
	Ecosystem Fragmentation							
	Riverine				/			
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification	Avoi throu
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	extensive)					
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avor throu
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types.	Request effect perm that
		Reduced foraging opportunities and rearing habitat availability					Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	qual

Minimization Measures	Resulting Effects of the Submechanism
arefully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on annel geometry, flow velocity, bstrate composition, and oundwater exchange to the greatest tent practicable.	May affect survival, growth, and fitness at egg, alevin, and juvenile life- history stages (river rearing sockeye). May affect spawning productivity.
void draining impounded area rough use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
void draining impounded area rough use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.
equire assessment of the hydraulic fects of the project before rmitting; avoid permitting designs at lead to disconnection of high ality floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.

Sub-Exposure activity **Mechanism of Impact** When Duration Life-history Form **Response to Stressor** Туре Stressor Frequency Aquatic Vegetation codification Riverine Juveniles: Decreased refuge habitat Altered autochthonous Reduced food web productivity, Year-round Permanent Continuous Juveniles; Av availability and foraging opportunities, production reduced foraging opportunity, thre Adults leading to increased competition and reduction in available cover Altered cover and habitat predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity. **Riparian Vegetation** Modification Riverine Altered stream bank and Increased suspended solids Year-round (with Intermediate-term to Continuous to Eggs and alevins; Eggs/alevins: Decreased incubation success Init seasonal (dependent due to decreased redd dissolved oxygen as shoreline stability specific stressors long-term (dependent me Juveniles; prominent during high on time required for on specific stressor) described for related stressor responses under cor Adults flow conditions) Water Quality Modification. riparian recovery) im dis <u>Juveniles:</u> Decreased refuge habitat sed availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for Spawning gravel sedimentation related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Rep Reduced recruitment of terrestrially Year-round Juveniles Juveniles: Reduced foraging opportunities Altered allochthonous Long-term to Continuous due to decreased food web productivity and inputs derived prey resources; reduced permanent nat decreased growth and fitness. aquatic food web productivity due to inv reduction in organic matter inputs Increased pollutant loading All exposed life-history stages: See related Rep Altered buffering capability Long-term to Continuous Year-round Eggs and alevins; stressor responses under Water Quality permanent nat Juveniles; inv Modification. Adults Rep Decreased dissolved oxygen from Year-round (most Seasonal Juveniles <u>Juveniles</u>: See related stressor responses Long-term to eutrophication (caused by elevated pronounced in spring permanent under Water Quality Modification. nat nutrient export) and summer when inv vegetation growth is most extensive)

Table A-5 (continued).HPA HCP Habita

Minimization Measures	Resulting Effects of the Submechanism
void draining impounded area rough use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.
itiate proper erosion control easures both during and after onstruction. Replant former npoundment with native vegetation to scourage invasives and stabilize diments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
eplant former impoundment with ative vegetation to discourage vasives and stabilize sediments.	May affect juvenile rearing.
eplant former impoundment with ative vegetation to discourage vasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
eplant former impoundment with tive vegetation to discourage vasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.

Sub-			Exp	osure	Γ	I		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification				-			
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins.Juveniles and adults:Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.Adults:Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini to ch short back pract proto turbi
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue envir area. comp
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limi Replanativ invas Avoi throu

Table A-5 (continued).HPA HCI

HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)

Construction and Maintenance Activities											
Riverine, Lacustrine, Marine											
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ref cont wate wor				

Minimization Measures	Resulting Effects of the Submechanism
Ensure project design avoids and/or ninimizes habitat alterations leading o chronic bank instability. Avoid hort-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and urbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
Limit damage to riparian area. Replant former impoundment with native vegetation to discourage nvasives and stabilize sediments. Avoid draining impounded area hrough use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
Refuel and service machinery in a controlled environment away from the vater body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Exp	osure	1	-				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.	

Sub-			Exp	osure	1				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
							<u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation.		
							<u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure.		
							<u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.		
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. <u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
							<u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.		

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity,	May affect survival, growth, and fitness at egg, alevin, and juvenile life history stages (river rearing sockeye). May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased refuge habitat during migration to lacustrine rearing environments, and increased predation exposure. Juvenile river rearing sockeye may also experience	substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition		Year round	Permanent	Continuous		decreased foraging opportunity, leading to increased competition and decreased growth and fitness.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

Table A-5	(continued).
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		<i>a.</i>	Ехро						Resulting Effects of the	
-	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism	
	Aarine						· · · · · ·		May affect survival, growth, and	
A	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Juvenile sockeye	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and productivity.	
A	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		have relatively limited dependence on nearshore marine habitats. However, alteration of habitat productivity in the nearshore may lead to alteration of food web dynamics in offshore environments, potentially affecting foraging opportunities, leading to decreased growth and productivity.	batterns.		
A	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		<u>Adults</u> : Alteration of nearshore habitat characteristics can demonstrably affect the productivity of forage species preyed upon by returning adult sockeye. Decreased foraging			
	Altered substrate omposition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	r-round (beginning project installation becoming more ounced over time , due to mulation of shell , sediment settling to altered wave or current regime, ine grounding,	Continuous		opportunity may lead to decreased growth and productivity.			
Ι	acustrine	1				1				
	Altered wave energy (short- eriod waves)	t- Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats upon which	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift	May affect growth and fitness at juvenile life-history stage. May aff adult spawning productivity.	
A	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		<u>Adults</u> : Alteration of nearshore habitat parameters may alter the suitability of shoreline spawning habitats for beach spawning sockeye, leading to decreased	patterns, and wave energy and current patterns.		
A	Altered sediment supply]	Year-round	Permanent	Continuous		spawning productivity.			
	Altered substrate omposition		Year-round	Permanent	Continuous]				
E	Cosystem Tragmentation				·					

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	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.
	Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. <u>Adults:</u> Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile l history stages. May affect adult survival and spawning productivity
-	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivi juvenile life-history stage. Decrea fitness may affect survival and productivity during ocean migratic life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Lacustrine			l	1			•	
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : LWD removal in lacustrine environments can fragment nearshore rearing and spawning habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life history stage. Decreased fitness m lead to reduced spawning producti

			Exp	osure	ſ	1			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on autochthonous inputs from marine littoral vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	Potential effects resulting from thi impact mechanism are unknown.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors un Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Sockeye dependence on nearshore marine habitats is limited in comparison to other salmonids. Sockeye response to alteration of nearshore habitat complexity is currently a data gap.		Potential effects on juvenile socker resulting from this impact mechan are unknown. May affect adult gr and productivity.
						/	<u>Adults</u> : Reduction in nearshore habitat complexity may affect availability of forage for returning adult sockeye, affecting growth and productivity during spawning.		
Ī	Riverine and Lacustrine	•						•	
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Alteration of aquatic vegetation may indirectly affect food web dynamics, potentially leading to decreased foraging opportunities.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors ur Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles</u> : Alteration of aquatic vegetation may indirectly affect food web dynamics, potentially leading to decreased foraging opportunities.		May affect juvenile survival.

Table A-5 (continued).HPA H

		Exp	oosure					Resulting Effects of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Riparian Vegetation Modification								
Riverine								
Altered shading, solar inp and ambient air temperatu		Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. N affect adult survival and spawnin productivity.
Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. M affect adult survival and spawning productivity.
Altered habitat complexit	 Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater) 	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning suc and overall population productivi
Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. <u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawnin productivity.

Sub-			Exp	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Marine	-						-
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Juvenile sockeye dependence on the nearshore marine environment is relatively limited. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoi ripari appro the g
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoi ripari appro the g
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on allochthonous inputs from marine riparian vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment.	Avoi ripari appro the g
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Sockeye dependence on nearshore marine habitats is limited in comparison to other salmonids. Sockeye response to alteration of nearshore habitat complexity is currently a data gap. <u>Adults</u> : Reduction in nearshore habitat complexity may affect availability of forage for returning adult sockeye, affecting growth and productivity during spawning.	Enco perm habit
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoi shore
	Lacustrine							
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoi ripari appro the g

Minimization Measures	Resulting Effects of the Submechanism					
roid/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to greatest extent possible.	May affect juvenile survival and growth.					
void/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to greatest extent possible.	May affect juvenile survival and fitness.					
void/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to a greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.					
courage project designs that limit rmanent alteration of high-quality bitat features.	Potential effects on juvenile sockeye resulting from this impact mechanism are unknown. May affect adult growth and productivity.					
oid disturbance of vegetation along preline.	Effects of the action resulting from this impact mechanism are unknown.					
void/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile survival, growth, and fitness.					

)-			Exp	osure					
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential reduction in egg survival and incubation success (for beach spawning sockeye) due to increased sedimentation and turbidity, as described under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg and alevin survival. May affect juvenile survival and productivity. May affect adult spawning productivity.
							Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.		
							<u>Adults</u> : May affect spawning habitat suitability, leading to decreased spawning productivity as described under Water Quality Modification.		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on autochthonous inputs from lacustrine riparian vegetation is a data gap. Sockeye are primarily planktonic feeders in the photic zone, so direct dependence on allochthonous inputs for prey is likely limited.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Intermediate-term to permanent (dependent on nature of activity and time required for recovery)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth and fitness.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased egg and alevin survival (beach-spawning sockeyes) due to lower dissolved oxygen levels in spawning substrate. <u>Juveniles</u> : Sockeye dependence on	Avoid disturbance of vegetation along shoreline.	May affect egg and alevin survival. May affect adult spawning productivity. Effects on juveniles an unknown.
							groundwater inflow to nearshore habitats is currently a data gap. <u>Adults</u> : Decreased suitable spawning habitat, leading to decreased spawning productivity.		

Sub-								
activity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification							
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu min to cl shor back prac prot turb
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensu dras com
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensu dras com

Table A-5 (continued).HPA HCP Ha

Minimization Measures	Resulting Effects of the Submechanism				
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.				
sure project design does not astically reduce hydraulic mplexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.				
sure project design does not astically reduce hydraulic mplexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.				

		Exp	osure								
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
ning Substrate Au	gmentation										
Construction and Maintenance Activities											
Riverine											
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.			
	Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific nois disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pi driving) may lead to direct mortal injury limiting to survival.			

		Exp	osure						
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.	
						<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.			
						<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.			
	Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.	
	Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.	
	Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitn See effects for related stressors on a life-history stages under Water Qua Modification.	
Hydraulic and Geomorphic Modification									
Riverine									
Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning succe and overall population productivity	
						<u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.			

			Exp	osure	1	1		
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Care desi impa proj desi
	Altered substrate composition/stability			Short-term to long- term			Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased refuge habitat during migration to lacustrine rearing environments, and increased predation exposure. Juvenile river rearing sockeye may also experience decreased foraging opportunity, leading to increased competition and decreased growth and fitness. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	chan subst grou: exter
	Aquatic Vegetation Modification Riverine							
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoi proje vege habit
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	

HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

survival, growth, and fitness.

<u>Adults</u>: Decreased foraging opportunity due to decreased food web productivity.

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on annel geometry, flow velocity, ostrate composition, and oundwater exchange to the greatest ient practicable.	May affect survival, growth, and fitness at egg, alevin, and juvenile life- history stages (river rearing sockeye). May affect spawning productivity.
oid spawning gravel augmentation ojects in locations where aquatic getation plays a strong role in bitat productivity.	May affect juvenile survival, growth, and fitness.

Sub-	_		Exp	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification		-	-	-			
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ens min to c sho bacl prac prot turb

Table A-5 (continued).HPA H

HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Construction and Maintenance Activities Riverine Equipment Operation Elevated Hydrocarbons (associated During project Temporary to short-Eggs and alevins; All life-history stages: Physiological Ref Interannual to with potential fuel and oil spills) construction activities term decadal responses to exposure at toxic levels, causing con Juveniles; mortality or injury leading to reduced fitness. wat Adults Bioaccumulation of contaminants at subacute wo levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.

Minimization Measures	Resulting Effects of the Submechanism
asure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
efuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-			Ехр	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity	Juveniles	Potential migration delay, leading to reduced spawning productivity. <u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	frequency) Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub-			Exp	osure	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification		-		-	-		
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins.Juveniles and adults:Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.Adults:Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensur minir to chr short- backg practi proto turbic
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contro water work

Table A-5 (continued).HPA HC

HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Riparian Planting/Restoration Enhancement

Construction and Maintenance Activities							
Riverine , Lacustrine, Marine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Mini speci assur speci

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
fuel and service machinery in a ntrolled environment away from the tter body. Limit heavy machinery ork within the channel.	May affect survival, growth, and fitness of juveniles and adults.
nimize disturbance during invasive ecies removal. Use measures to sure rapid establishment of planted ecies.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-			Exp	osure		-		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Minir specie erosic after o
		Spawning gravel sedimentation – due to removal of invasive riparian species					Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	
	Aquatic Vegetation Modification						Houneaton.	
	Riverine, Lacustrine, Marine					V		
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sockeye dependence on autochthonous inputs from marine littoral vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment.	Desig canop contir

Minimization Measures	Resulting Effects of the Submechanism
inimize disturbance during invasive eccies removal. Use appropriate osion control BMPs both during and er construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
ssign riparian patches with variable nopy coverage so that sunlight will ntinue to reach the channel.	Potential effects resulting from this impact mechanism are unknown.

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification			-		-	•		
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-5 (continued).HPA HCP Habi

-		Exp	osure	Г	-		Resulting Effects of the	
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
nd Creation Res	toration/Enhancement							
Construction and Maintenance Activities								
Riverine and Marine								
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific no disturbance intensity and recepto exposure. Exposure to intense underwater noise sources (e.g., p driving) may lead to direct morta injury limiting to survival.

		Exp	osure	1	1	4		Doculting Efforts of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.
						<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning		
						habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortal juveniles and adults. Stress may survival, growth and fitness, and spawning productivity.
						decreased fitness and spawning success.		
	Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or inj juvenile life-history stage. Injury stress may affect survival, growth fitness.
	Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. <u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May adult fitness and spawning productivity.
						<u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.		
	Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

		Exposure						
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor		
Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause		

During project

construction activities

HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Eggs and alevins;

Juveniles;

Adults

Beach Nourishment/Contouring

Altered Pollutant Loading

Elevated Hydrocarbons (associated

with potential fuel and oil spills)

Subactivity Туре

Marine and Lacustrine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate mach proje
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles;	Eggs and alevins: Littoral disturbance in lacustrine areas may lead to direct mortality and decreased survival of eggs and alevins. Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoi produ comu activ perio

Temporary to short-

term (dependent on

contributing

impact)

mechanism of

Interannual to

decadal

Minimization Measures	Resulting Effects of the Submechanism
Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
Avoid project site which are productive and have a healthy benthic community. Avoid lacustrine activities during sockeye spawning periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage.

physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered

Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and

All life-history stages: Physiological

responses to exposure at toxic levels, causing

mortality or injury leading to reduced fitness.

Bioaccumulation of contaminants at subacute

levels, resulting in chronic physiological

effects leading to reduced fitness and/or

migration behavior.

mortality.

reduced spawning success.

ty	F		Exp	osure	Г	1	4		Resulting Effects of the		
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism		
	Hydraulic and Geomorphic Modification								-		
	Marine and Lacustrine	_					-	-			
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles;	Eggs and alevins: Littoral disturbance in lacustrine areas may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect survival of incubating e and alevins. May affect growth and fitness at juvenile life-history stage		
	Aquatic Vegetation Modification										
	Marine and Lacustrine										
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Sockeye dependence on autochthonous inputs from marine littoral vegetation is a data gap but is likely limited due to the lesser dependence of this species on	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	Potential affects on juveniles is unknown. May affect adult growth and spawning productivity.		
	Altered cover and habitat	Reduced cover					the nearshore marine environment. <u>Adults</u> : Reduction in nearshore habitat complexity may affect availability of forage for returning adult sockeye, affecting growth and productivity during spawning.				
	Water Quality Modification										
	Marine and Lacustrine										
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating e and alevins. May affect juvenile growth and fitness and adult productivity and spawning success		
							<u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.				
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.		

Table A-5 (continued).HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

ub-			Exp	oosure				
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
eef C	reation/Restoratio	n/Enhancement						
	Construction and Maintenance Activities							
	Marine and Lacustrine							
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avo perio preso
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avo noise equi tech
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles;	Eggs and alevins: Littoral disturbance in lacustrine areas may lead to direct mortality and decreased survival of eggs and alevins. Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avo prod com activ perio

Minimization Measures	Resulting Effects of the Submechanism
roid construction activities during riods when individuals may be esent, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
void/minimize cavitation to limit ise intensity. Promote use of vessels uipped with antinoise/antivibration hnology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
roid project site which are oductive and have a healthy benthic mmunity. Avoid lacustrine ivities during sockeye spawning riods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage.

Sub-			Exp	osure	_				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and fitness,
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Sockeye salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity,	patterns, and wave energy and current patterns.	and spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		decreased fitness for marine migration, and direct mortality. <u>Adults</u> : Adult Sockeye salmon forage in nearshore environments during return		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		migrations. Alteration of nearshore habitat characteristics through these sub-mechanisms may lead to decreased food web productivity and prey availability. This may lead to decreased growth and decrease spawning fitness.		

Table A-5 (continued).HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

			Expo	osure	ſ			
t y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Lacustrine							
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats upon which	Care desi impa proj proj on s patte
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous		juvenile sockeye depend. <u>Adults:</u> Alteration of nearshore habitat parameters may alter the suitability of shoreline spawning habitats for beach spawning sockeye, leading to decreased	patt
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		spawning productivity.	
	Altered sediment supply		Year-round	Permanent	Continuous			
	Altered substrate composition		Year-round	Permanent	Continuous			
	Ecosystem Fragmentation				•			
	Marine							
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoi prox corri pred
	Lacustrine		I					
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avo prox corri pred
	Aquatic Vegetation Modification							
_	Marine Altered cover and habitat	Increased predation risk	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due	Avo
F	.						to decreased food web productivity.	
	Lacustrine			~.				
	Altered autochthonous	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature	Continuous	Juveniles;	<u>Juveniles:</u> Decreased refuge habitat availability, leading to increased competition and resulting effects on growth and fitness.	Avo: vege
	production Altered cover and habitat							

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selections of oject designs that minimize effects sediment supply, longshore drift tterns, and wave energy and current tterns.	May affect growth and fitness at juvenile life-history stage. May affect adult spawning productivity.
yoid placement of reef projects in oximity to juvenile migratory rridors, such that increased edation exposure may occur.	May affect juvenile survival, growth and fitness.
void placement of reef projects in oximity to juvenile migratory rridors, such that increased edation exposure may occur.	May affect juvenile survival, growth and fitness.
void/minimize disturbance of aquatic getation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
oid/minimize disturbance of aquatic getation during project construction.	May affect juvenile survival, growth, and fitness.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Caref desig impa proje desig sedin patter patter
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use n

HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement

Construction and Maintenance Activities							
Marine							
Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhe work
Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoi abov exter estab sedir

Resulting Effects of the Submechanism
May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
May affect survival, growth, and fitness of juveniles and adults.
May cause temporary behavioral avoidance and displacement.
May cause temporary behavioral avoidance and displacement.

Sub-			Ex	posure	1				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver	: Dam Removal								
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom increased flow entrainment asimpoundment dewatering.Possible strandingof alevins in impoundment areas.Adults and juveniles:Mortality, injury, orstress from stranding or entrainment indewatering flows.Juveniles:Increased competition followingdisplacement, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration, resulting indecreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-6	(continued).
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			Ex	posure	,					
Ÿ	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Hydraulic and Geomorphic Modification	-		-	-	-		-	-	
	Riverine				-			-		
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring flows. Encourage use of beaver deceivers.	May affect survival at egg, alevin, an juvenile life-history stages. May affe spawning productivity.	
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase			
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal		competition for suitable habitats, leading to decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased			
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous		survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification.			
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is			
							affected.			
	Ecosystem Fragmentation									
	Riverine									
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen Decreased dissolved oxygen from	Year-round (most pronounced in summer and autumn when vegetation growth and decay is	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.	
		eutrophication below the impoundment (caused by elevated nutrient export)	most extensive)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.	

			Ex	posure					
Mechanis	sm of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Altered terrestrial/ac connectivity		Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density- dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, alevin, an juvenile life-history stages. May affe spawning productivity.
Aquatic Veg Modification									
Riverine									
Altered autoc production Altered cover		Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.
Riparian Ve Modification									
Riverine									
Altered stream shoreline stat		Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
Altered alloch	chthonous	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to	Year-round	Long-term to permanent	Continuous	Juveniles	Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.

-			Ex	posure										
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	n Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism					
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification					
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification					
	Water Quality Modification													
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.					
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages:</u> Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.					
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival productivity, and spawning success.					

			Ex	posure		· · · · · · · · · · · · · · · · · · ·	-		Descrikter e Fifte et al. e 41
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
ne or	Voody Debris ent/Movement/Re astruction impacts Construction and Maintenance Activities	moval (for placement s apply)							
	Riverine, Lacustrine, Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noi disturbance intensity and recepton exposure. Exposure to intense underwater noise sources (e.g., pi driving) may lead to direct mortal injury limiting to survival.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs and alevins, juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Mechanism of Impact			posure	1	_			
inteenument of impute	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
	Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
Hydraulic and Geomorphic Modification								
Riverine								
Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at egg, alevin, and juvenile life-history stages. May affec spawning productivity.
Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
Altered substrate composition		Year round	Permanent	Continuous		decreased growth, fitness, and survival.		
Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is		
	Geomorphic Modification Riverine Altered channel geometry Altered flow velocity Altered substrate composition Altered groundwater-	increased suspended solids, resuspension of contaminated sediments Hydraulic and Geomorphic Modification Riverine Altered channel geometry Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability Altered flow velocity Altered substrate composition Altered groundwater-	Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments During project construction and maintenance activities Hydraulic and Geomorphic Modification Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments During project construction and maintenance activities Riverine Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability Year-round Altered flow velocity Var-round (with stressor exposure occurring during high-flow events, fall through spring) Year round Altered groundwater-surface water exchange Vear-round (with stressor exposure occurring during egg incubation and juvenile Year-round (with stressor exposure occurring during egg incubation and juvenile	Image: construction and maintenance activitiesTemporary to short- termEntrainment of benthic organisms, increased suspended solids, resuspension of contaminated sedimentsDuring project construction and maintenance activitiesTemporary to short- termHydraulic and Geomorphic Modification	maintenance activitieson activity frequency)Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sedimentsDuring project construction and maintenance activitiesTemporary to short- termInterannual-decadalHydraulic and Geomorphic ModificationExercontaminatedDuring project construction and maintenance activitiesTemporary to short- termInterannual-decadalHydraulic and Geomorphic ModificationExercontaminatedSecondaryInterannual-decadalRiverineSchange in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitabilityYear-round (with stressor exposure occurring during high- flow events, fall through spring)PermanentContinuousAltered flow velocityAltered groundwater- surface water exchangeYear-round (with stressor exposure occurring during events, for events, fall through spring)PermanentContinuous	maintenance activitieson activity frequencyEntrainment of benthic organisms, increased suspended solids, resuspension of contaminated sedimentsDuring project construction and maintenance activitiesTemporary to short- termInterannual-decadalEggs and alevins; Juveniles; AdultsHydraulic and Geomorphic ModificationEventEventEventEventReverineNorder Structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitabilityYear-round (with stressor exposure occurring during high- flow events, fail through spring)PermanentContinuousEggs and alevins; Juveniles; AdultsAltered substrate compositionContinuousPermanentVear-round (with stressor exposure occurring during high- flow events, fail through spring)PermanentContinuousAltered substrate compositionVear-round (with stressor exposure occurring during high- flow events, fail through spring)PermanentContinuousAltered substrate compositionVear-round (with stressor exposure occuring during high- flow events, fail through spring)PermanentContinuous	Image: set in the set of the set is increased superiod of solids. During project construction and increased superiod solids. Temporary to short increased superiod solids. East and lexing: Montality or injury from entraneme. Hydraulic and Generation of construction and increased superiod solids. During project construction and increased superiod solids. Temporary to short increased superiod solids. Eages and alexing: Montality or injury from entraneme. Hydraulic and Generation of Construction and increased superiod solids. Temporary to short increased superiod and fitness. Alulits Eages and alexing: Montality or injury from entraneme. Hydraulic and Generation of Construction and increase of the state solid solid set structure and labitist. Temporary to short increase set set set set set set set set set s	Image: set of the set

Table A-6	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile steelhead. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. <u>Adults</u> : Subadult and returning adult steelhead forage in nearshore environments. Alteration in nearshore ecosystem processes may decrease foraging opportunity, affecting growth and fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult growth and productivity.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent			patterns, and wave energy and current patterns.	
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-6	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

	-		Ex	posure					
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival, growth, and fitness at juvenile life-history stage May affect adult fitness and spawn productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult steelhead. This may occur through a number of specific stressors, including increased exertion and stress due to change in	patterns, and wave energy and current patterns. For example:	
	Altered sediment supply		Year-round	Permanent	Continuous		current and wave energy patterns, increased		
	Altered substrate composition		Year-round	Permanent	Continuous		predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult steelhead will generally be less sensitive to these stressors. However, increased stress and delayed migration may reduce fitness and ultimately reduce spawning success.		
	Ecosystem Fragmentation								
-	Riverine Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modificati
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

			I	Exposure					
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
_	Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat	Reduced availability of off- channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density- dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. <u>Juveniles</u> : Decreased refuge habitat	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile life history stages. May affect adult survival and spawning productivity.
	connectivity	habitats along longitudinal gradient.					availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. <u>Adults:</u> Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		
	Marine	•	·	·					
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : LWD removal in the marine environment may fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
Ī	Lacustrine					·			
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.

Table A-6	(continued).
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			Ex	posure								
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Aquatic Vegetation Modification											
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness			
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.			
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile survival. May affect adult growth and spawning productivity.			
ſ	Riverine and Lacustrine	•		·			•					
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness			
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.			
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.			

Table A-6	(continued).
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			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification	÷	<u>.</u>	-		2	•	•	•
1	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning succe and overall population productivity
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. <u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.

			Ex	posure					
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. The extent of nearshore habitat use by juvenile steelhead is currently a data gap. However, juveniles trapped by tidal exchange in specific habitats, such as pocket estuaries, may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival and growth.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. This effect may be limited in magnitude, however, as juvenile steelhead use of littoral habitats is relatively limited. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, steelhead are known to use terrestrial insect resources recruited from the riparian zone in freshwater environments, so exploitation of these resources in marine environments is possible.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Steelhead dependence on nearshore habitat complexity is currently a data gap. Altered habitat complexity may lead to decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival, growth, and fitness.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from th impact mechanism are unknown.

			Ex]	posure					
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, steelhead are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and productivity.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and fitness, spawning success, and overall population productivity.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Steelhead dependence on groundwater inflow to littoral lacustrine habitats is currently a data gap. However, loss of groundwater may lead to reduction in shallow water thermal refuge, increased competition, and decreased foraging opportunity.	Avoid disturbance of vegetation along shoreline.	May affect juvenile survival and fitness.

Table A-6	(continued).
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-			Ex	posure					
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating e and alevins. May affect juvenile survival, growth, and fitness, and a survival and spawning productivity
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitnes as well as adult survival, fitness, an spawning success.

			Ex	posure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
wn	ning Substrate Aug	mentation							
	Construction and Maintenance Activities								
	Riverine								
Equipment Operation	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, an fitness of juveniles and adults.
	Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific no disturbance intensity and recepto exposure. Exposure to intense underwater noise sources (e.g., p driving) may lead to direct mort injury limiting to survival.	

			Ex	posure	r	r				
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.	
							<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.			
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.			
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or inju- egg, alevin, and juvenile life-histo stages. Injury and stress may affec survival, growth, and fitness.	
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.	
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fit See effects for related stressors on life-history stages under Water Qu Modification.	
	Hydraulic and Geomorphic Modification									
ŀ	Riverine									
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning suc and overall population productivi	

			Ex	posure					
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects) Altered substrate composition/stability	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term Short-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. <u>Juveniles</u> : Altered channel geometry, bank stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	May affect survival at egg, alevin juvenile life-history stages. May spawning productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, gro and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.		

		Ex	posure		1			
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Water Quality Modification		-		-	-		-	
Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating and alevins. May affect juvenile growth and fitness and adult productivity and spawning succe
Construction and Maintenance Activities	Habitat Creation/Modifie	cation						
Riverine								
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Exp	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-			Ex	xposure	T	r	_		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

			Ex	posure					
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification		•	•		-	•	•	•
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
aria	an Planting/Restor	ation Enhancement							
	Construction and Maintenance Activities								
ľ	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Riverine , Lacustrine, Marine						
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.

Table A-6	(continued).
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			Ex	posure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitnes

Table A-6	(continued).
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			Ex	posure		-			
ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u> : Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins.Juveniles and adults:Responses vary depending on stressor magnitude.Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.Adults:Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

			Ex	posure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
tlan	nd Creation Restor	ation/Enhancement							
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noi disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pi driving) may lead to direct morta injury limiting to survival.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities,	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affec survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

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ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification	•	-		•	-	•	•	-
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
each	Nourishment/Cont	ouring							
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Construction and Maintenance Activities											
Marine and Lacustrine											
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate mach proje				
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoi produ comr				

Table A-6	(continued).
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			Ex	posure							
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Hydraulic and Geomorphic Modification			-					-		
	Marine and Lacustrine										
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.		
	Aquatic Vegetation Modification										
	Marine and Lacustrine										
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. Ma affect adult growth and spawning productivity.		
	Altered cover and habitat	Reduced cover					survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	production regeneric aquate meridan			
Water Quality Modification											
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults:Responses vary depending on stressor magnitude.Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.Adults:Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating and alevins. May affect juvenile growth and fitness and adult productivity and spawning succes		
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.		

ity			Ex	posure			_		Resulting Effects of the
•	nism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
f Creation/	/Restoration	n/Enhancement							
Constructi Maintenar	tion and ince Activities								
Marine an	nd Lacustrine								
Equipment materials p	t operation and placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions: may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-histo stages, depending on project-speci noise intensity and receptor expos Should exposure occur, direct mortality or injury is probable.
Construction	ion vessel	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	J <mark>uveniles</mark> ; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior decreased foraging success, and increased predation risk.
Bank, chan disturbance	nnel, shoreline ce	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
								connunty.	

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification		-	-		-			
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile steelhead. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. <u>Adults</u> : Subadult and returning adult steelhead forage in nearshore environments. Alteration in nearshore ecosystem processes may decrease foraging opportunity, affecting growth and fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult growth and productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-6	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

	Mechanism of Impact		Exj	posure					
		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short- period waves)	aves) suitability; reduced food web complexity, habitat availability, and suitability mediced food web complexity, habitat availability, and suitability mediced food web suitability mediced food web suitability mediced food web suitability mediced food web suitability, and suitability mediced food web suitability mediced food web suitability, and suitability mediced food web suitability mediced food web suitability, and suitability mediced food web suitability mediced food we	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult fitness and spawnin productivity.					
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult steelhead. This may occur through a number of specific stressors, including increased exertion and stress due to change in	patterns. For example: for a ge in sed or	
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal	current a predation exposur alteration opportu	current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging		
	Altered sediment supply		Year-round	Permanent	Continuous		opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult steelhead will generally be less sensitive to these stressors. However, increased stress and delayed migration may reduce fitness and ultimately reduce spawning success.		
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, grow and fitness.
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, grow and fitness.

Table A-6	(continued).
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			Ez	posure					
ty Mechanism of	f Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Aquatic Vegetati Modification	ion	-		-	-	-		-	-
Marine		-			-		-	-	
Altered cover and	l habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults:</u> Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
Lacustrine									
Altered autochtho production		Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature	Continuous	Juveniles;	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growth and fitness.
Altered cover and	l habitat			of activity)			effects on growth and fitness.		
Water Quality Modification				-			·		
Altered suspended	d solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
Altered pollutant l	loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

)-			Ex	posure					
rity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
avei	: Dam Removal								
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom increased flow entrainment asimpoundment dewatering.Possible strandingof alevins in impoundment areas.Adults and juveniles:Mortality, injury, orstress from stranding or entrainment indewatering flows.Juveniles:Increased competition followingdisplacement, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration, resulting indecreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality juveniles and adults. Stress may affe survival, growth and fitness, and adu spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors unde Water Quality Modification.

7			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification			-	-				
	Riverine		-		-		-	-	
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring	May affect survival at egg, alevin, an juvenile life-history stages. May affer spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased	flows. Encourage use of beaver deceivers.	
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous		survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-7	(continued).
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			Ex	posure						
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, alevin, an juvenile life-history stages. May aff spawning productivity.	
		Reduced foraging opportunities and rearing habitat availability					dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.			
	Aquatic Vegetation Modification									
Riverine										
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.	
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.			
	Riparian Vegetation Modification									
Ľ	Riverine									
	Altered stream bank and shoreline stability	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.	
		Spawning gravel sedimentation					related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.	

b-	Mechanism of Impact		Ex	posure					
tivity pe		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
-	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

			Ex	posure	r	-		Domiking Fifty (4)	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
me COI	Voody Debris ent/Movement/Re istruction impact	emoval (for placement s apply)							
	Maintenance Activities Riverine, Lacustrine,								
	Marine, Lacustrine,								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noi disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pi driving) may lead to direct mortal injury limiting to survival.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs and alevins, juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

ıb-			Exposure						
tivity /pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitnes See effects for related stressors on all life-history stages under Water Qualit Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition		Year round	Permanent	Continuous		decreased growth, fitness, and survival. Adults: Changes in channel morphology may		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is		

Table A-7	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Exj	posure	1	1			
activity Type	Mechanism of Impact	Stressor	When	WhenDurationFrequencyLife	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Coastal cutthroat trout. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction		May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.		

Table A-7	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

	-		Ex	posure	· ·	,			
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival at juvenile life history stage. Decreased fitness m lead to reduced spawning production
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Coastal cutthroat trout. This may occur through a number of specific stressors, including increased exertion and stress due to	patterns, and wave energy and current patterns.	
	Altered sediment supply		Year-round	Permanent	Continuous		change in current and wave energy patterns,		
	Altered substrate composition		Year-round	Permanent	Continuous		increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Coastal cutthroat will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.		
	Ecosystem Fragmentation								
ļ	Riverine		1			-	1		1
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modificat
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		May affect survival, growth, an fitness of juveniles and adults.

Table A-7	(continued).
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		Ex	posure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat	Reduced availability of off- channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density- dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. <u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities,	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile lif history stages. May affect adult survival and spawning productivity.
connectivity	habitats along longitudinal gradient.					Adults: Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		
Marine								
Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	All exposed life-history stages: LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
Lacustrine								
Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivit
Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.

Table A-7	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

		Ex	posure										
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism					
Aquatic Vegetation Modification	ification												
Marine													
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness					
	Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.					
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile survival. May affect adult growth and spawning productivity.					
Riverine and Lacustrine								I					
Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.					
	Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.					
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.					

HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

y			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification	-	-	-	-	-		-	
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning succ and overall population productivity
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. <u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.

			Ex	posure					
rity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine	-					-	-	-
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coastal cutthroat dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, Coastal cutthroat are known to utilize terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coastal cutthroat dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.

			Exj	posure	T				
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coastal cutthroat are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitne
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Coastal cutthroat dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along the shoreline.	Effects of the action resulting from the impact mechanism are unknown.

HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

			Ex	posure	-				
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification	-	-	-	-	-	-	-	
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating e and alevins. May affect juvenile survival, growth, and fitness, and a survival and spawning productivity
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitnes as well as adult survival, fitness, and spawning success.

,			Ex	posure	1									
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism					
ni	ng Substrate Aug	mentation												
	Construction and Maintenance Activities													
	Riverine													
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.					
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific no disturbance intensity and recepto exposure. Exposure to intense underwater noise sources (e.g., p driving) may lead to direct morta injury limiting to survival.					

,			Ex	posure	·	r			Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs and alevins, juveniles</u> : Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitn See effects for related stressors on a life-history stages under Water Qua Modification.
	Hydraulic and Geomorphic Modification								
	Riverine	1	[Т	1	1		r	I
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning succe and overall population productivity

	Mechanism of Impact		Ex	posure					
		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects) Altered substrate composition/stability	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term Short-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. <u>Juveniles</u> : Altered channel geometry, bank stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	May affect survival at egg, alevin, a juvenile life-history stages. May aff spawning productivity.
	Aquatic Vegetation Modification Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.		

			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification	-	-	-	-	-	-		
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubatir and alevins. May affect juvenil growth and fitness and adult productivity and spawning succ
	Construction and	Habitat Creation/Modific	cation						
- 1	Maintenance Activities Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-			Ex	posure	.	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Table A-7	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

			Ex	posure		_			
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification				-				
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
aria	an Planting/Restor	ation Enhancement							
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u> : Decreased spawning fitness due to	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Riverine , Lacustrine, Marine						
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.

HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Exj	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness

Table A-7	(continued).
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		Exposure							
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification		-		-	-			
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u> : Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

			Ex	posure									
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism				
tlano	d Creation Restor	ation/Enhancement											
	Construction and Maintenance Activities												
	Riverine and Marine												
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.				
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noi disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pi driving) may lead to direct mortal injury limiting to survival.				

HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Ex	posure	_				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

			Ex	posure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
lh I	Nourishment/Cont	ouring					5		
	Construction and Maintenance Activities	0							
ľ	Marine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Construction and Maintenance Activities														
Marine and Lacustrine														
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contre water mach projec							
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid produ comm							

HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Ex	posure					
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification			•	-	•		-	-
	Marine and Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine and Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover				\land	survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.		
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

vity			Ex	posure	1	1			Resulting Effects of the
5	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
f C	reation/Restoratio	n/Enhancement							
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-histo stages, depending on project-spec noise intensity and receptor expos Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	J <mark>uvenil</mark> es; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Sub-			Ex	posure			_		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and fitness,
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				and spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		decreased fitness for marine migration, and direct mortality. <u>Adults</u> : Adult Coastal cutthroat trout forage in nearshore environments during return		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-7	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

			Ex	posure		- (_		
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival at juvenile life- history stage. Decreased fitness ma lead to reduced spawning production
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous	potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Coastal cutthroat trout. This may occur through a number of specific stressors,	patterns, and wave energy and current patterns.		
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging		
	Altered sediment supply		Year-round	Permanent	Continuous		opportunity, and increased competition for suitable habitats. The combined effect of		
	Altered substrate composition		Year-round	Permanent	Continuous		these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Coastal cutthroat will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.		
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growt and fitness.
ſ	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-7 (co	ontinued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

			Ex	posure					
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
1	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults:</u> Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
1	Lacustrine	•							
1	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature	Continuous	Juveniles;	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growth, and fitness.
4	Altered cover and habitat			of activity)			effects on growth and fitness.		
	Water Quality Modification						·		
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
atio	ss and Other Aqu n/Restoration/Enh								
	Construction and Maintenance Activities								

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

			Ех	posure					
v ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
avei	r Dam Removal								
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, grown and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom increased flow entrainment asimpoundment dewatering.Possible strandingof alevins in impoundment areas.Adults and juveniles:Mortality, injury, orstress from stranding or entrainment indewatering flows.Juveniles:Increased competition followingdisplacement, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration, resulting indecreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality juveniles and adults. Stress may aff survival, growth and fitness, and ad spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors und Water Quality Modification.

)-			Ex	posure					
vity De	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification		-	-	-	-		-	-
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Juveniles; Adults	<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects	May affect juvenile survival, growth and fitness. May affect adult spawning fitness.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		for suitable habitats, leading to decreased growth, fitness, and survival.	on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation		6,						
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	growth and decay is most extensive)						
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : This stressor may limit the availability of adult spawning and juvenile rearing habitat for trout species dependent on these habitat types. Decreased habitat availability may lead to density dependent offects on adult	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
		Reduced foraging opportunities and rearing habitat availability					lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.		

			Exj	oosure	r	1			
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification			-		-	-		
	Riverine								
	Altered autochthonous production	Reduced food web productivity, reduced foraging opportunity,	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities,	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning
	Altered cover and habitat	reduction in available cover					leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due		productivity.
	Riparian Vegetation						to decreased food web productivity.		
_	Modification Riverine								
F	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modificat
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification

Sub-			Ex	posure		.		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini to ch short back pract proto turbi
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu envir area. com
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limi Repla nativ invas Avoi throu

Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)

Construction and Maintenance Activities							
Riverine, Lacustrine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate work

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
fuel machinery in a controlled vironment away from the project ea. Avoid reducing hydraulic mplexity.	May affect survival, growth, and fitness of juveniles and adults.
nit damage to riparian area. plant former impoundment with tive vegetation to discourage vasives and stabilize sediments. roid draining impounded area ough use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
fuel and service machinery in a ntrolled environment away from the ter body. Limit heavy machinery rk within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Ex	posure	.				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Sub-			Ex	posure			_		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs and alevins, juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reduced	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

ub-			Ex	posure					
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects	May affect juvenile survival, growth and fitness. May affect adult spawnin fitness.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading	on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition		Year round	Permanent	Continuous		to increased stress and decreased spawning success.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

			Ex	posure					
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival and productivity at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult native trout. This may occur through a number of specific stressors, including increased	sediment supply, longshore drift patterns, and wave energy and current patterns. For example:	
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous		exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and fitness, and direct mortality. <u>Adults</u> : Adult native trout will generally be less sensitive to these stressors. However, increased stress and inhibited movement may reduce fitness and ultimately reduce spawning success.		
_	Ecosystem Fragmentation								
-	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub- activity			Ex	posure	1		4					
аснуну Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat connectivity	Reduced availability of off- channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density- dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. <u>Adults:</u> Decreased survival, fitness and spawning success due to decreased	Req hydi befo desi of fl long				
							availability of suitable migratory and spawning habitat.					
	Lacustrine			1	L							
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requ footj obje in ar effec				
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Enco pern habi				
	Aquatic Vegetation Modification											
	Riverine and Lacustrine											
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Cons</u> distu durii				
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.					

Minimization Measures	Resulting Effects of the Submechanism
equire assessment of the rdraulic effects of the project fore permitting; avoid permitting signs that lead to disconnection floodplain habitat or ngitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile life- history stages. May affect adult survival and spawning productivity.
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
courage project designs that limit rmanent alteration of high-quality bitat features.	May affect juvenile survival.

onstruction: Avoid/minimize sturbance of aquatic vegetation rring project construction.	May affect juvenile growth and fitness.
	See effects for related stressors under Water Quality Modification.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
							<u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

			Ex	posure	1	Υ			
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning succe and overall population productivity
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
	Lacustrine							•	
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Native trout dependence on allochthonous inputs from riparian vegetation is a data gap. However, native trout are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitnes and productivity.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.

Sub-			Ex	posure		7			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Native trout dependence on groundwater inflow to nearshore habitats is currently a data gap.	Avoid disturbance of vegetation along stream.	Effects of the action resulting from this impact mechanism are unknown.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

)-			Ex	posure	1				
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
pawr	ning Substrate Aug	mentation			1				
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortalit injury limiting to survival.

Table A-8 (continued).	HPA HCP Habitat Modification Ex	xposure and Response Matrix for	Native Trout (Westslope Cutthroat an
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			Ex	posure	1				
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.
							<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or inju- egg, alevin, and juvenile life-histor stages. Injury and stress may affec survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fit See effects for related stressors on life-history stages under Water Qu Modification.
	Hydraulic and Geomorphic Modification								
Riverine									
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning suc- and overall population productivi
							<u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		

and Redband Trout).

			ŀ	Exposure					
r	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects) Altered substrate composition/stability	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term Short-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. Juveniles: Altered channel geometry, bank stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	May affect survival at egg, alevin, ar juvenile life-history stages. May affe spawning productivity.
							beneficial effects would be expected to persist.		
	Aquatic Vegetation Modification								
Ē	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.		

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ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification							-	
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating e and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
Cha	annel/Off-Channel	Habitat Creation/Modific	cation						
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-8 (continued).	HPA HCP Habitat Modification Exposure and Response	e Matrix for Native Trout (Westslope Cutthroat ar
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Sub-			Ех	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

and Redband Trout).

Table A-8 (continued).	HPA HCP Habitat Modification Exposure and Response Matrix for Native	Trout (Westslope Cutthroat an

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. <u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Potential migration delay, leading to reduced spawning productivity. <u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

and Redband Trout).

			Ex	posure			_		
rity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification	-	-	•	2	-		-	÷
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
ari	an Planting/Restor	ation Enhancement							
	Construction and Maintenance Activities								
	Riverine , Lacustrine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u> : Decreased spawning fitness due to migration delays caused by thermal barriers.		

Riverine, Lacustrine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due towinter ice formation and scour.Juveniles:Altered growth and survivalcaused by temperatures outside optimalgrowth range and alteration of food webpatterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration delays caused by thermal barriers.	Min spec assu spec

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vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification Riverine, Lacustrine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitnes

Sub-			Ex	posure					fitness May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity. May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	
	Riparian Vegetation Modification		-	-					
	Riverine, Lacustrine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

			Ex	posure		,			
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
and	l Creation Restor	ation/Enhancement							
	Construction and Maintenance Activities								
F	Riverine								
E	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	a May affect survival, growth, and fitness of juveniles and adults. ery May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise o disturbance intensity and receptor s. exposure. Exposure to intense ain to underwater noise sources (e.g., pile vithin driving) may lead to direct mortality of injury limiting to survival.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	fitness at all life-history stages, depending on project-specific nois disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pil driving) may lead to direct mortali

Sub-			Ex	posure		. <u></u>			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

			Ex	posure		-			
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification	-			-			-	-
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
ch	Nourishment/Cont	touring							
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Construction and Maintenance Activities							
Lacustrine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contre water mach projec
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid produ comm

			Ex	posure					
r	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. Ma affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover					survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.		
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating and alevins. May affect juvenile growth and fitness and adult productivity and spawning succes
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	reduced spawning success. <u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Sub-				Γ						
activity Type	Mechanism of Impact	Stressor	When	posure Duration	Frequency	Life-history Form	Response to Stressor			
Reef C	reation/Restoration	n/Enhancement								
	Construction and Maintenance Activities									
	Lacustrine									
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Av pe pr		
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Av no eq tec		
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Av pro		

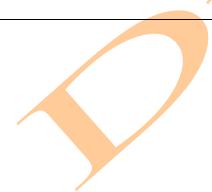
Minimization Measures	Resulting Effects of the Submechanism			
void construction activities during priods when individuals may be esent, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.			
void/minimize cavitation to limit bise intensity. Promote use of vessels uipped with antinoise/antivibration chnology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.			
void project site which are oductive and have a healthy benthic ommunity.	May affect growth and fitness at juvenile life-history stage.			

	Exposure									
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Hydraulic and Geomorphic Modification	-	-	-	-	-	-	-	-	
]	Lacustrine									
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult native trout. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns. For example:	May affect survival and productivity a juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.	
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous					
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal					
	Altered sediment supply		Year-round	Permanent	Continuous					
	Altered substrate composition		Year-round	Permanent Continuous		decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and fitness, and direct mortality. <u>Adults</u> : Adult native trout will generally be less sensitive to these stressors. However,				
							increased stress and inhibited movement may reduce fitness and ultimately reduce spawning success.			
]	Ecosystem Fragmentation									
	Lacustrine									
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growt and fitness.	
	Aquatic Vegetation Modification									
	Lacustrine									
1	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature	Continuous	Juveniles;	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growt and fitness.	
	Altered cover and habitat			of activity)			effects on growth and fitness.			

b-			E	xposure					
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating egg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Not applicable



ub-			Ex	posure					
tivity 7pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
eave	r Dam Removal								
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom increased flow entrainment asimpoundment dewatering.Possible strandingof alevins in impoundment areas.Adults and juveniles:Mortality, injury, orstress from stranding or entrainment indewatering flows.Juveniles:Increased competition followingdisplacement, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration, resulting indecreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

			Ex	posure			-		
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification							-	
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase	flows. Encourage use of beaver deceivers.	
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal		competition for suitable habitats, leading to decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased		
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous		survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification.		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
Ì	Ecosystem Fragmentation					I			
	Riverine		-						
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	growth and decay is most extensive)						
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

			Ex	posure								
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density- dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.			
	Aquatic Vegetation Modification											
	Riverine											
-	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.			
							survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.					
	Riparian Vegetation Modification											
	Riverine											
-	Altered stream bank and shoreline stability	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.			
		Spawning gravel sedimentation					related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.					
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.			

Table A-9 (continued).	HPA HCP Habitat Modification Exposure and Response Matrix for Bu	Ill Trout and Dolly	Varden (N
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Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

(Native Char).

			Ex	posure					
Mechanism	of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
e Woody De ment/Move construction	ment/Re	moval (for placement 5 apply)							
Construction Maintenance									
Riverine, Lac Marine	ustrine,								
Equipment Op	eration	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages:</u> Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pil driving) may lead to direct mortals injury limiting to survival.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Table A-9 (continued).	HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout	and Dolly Varden (N
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			Ex	posure		1			
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition		Year round	Permanent	Continuous		competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		Addits: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

(Native Char).

		Ex	posure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Marine								
Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift	May affect juvenile and adult survi and growth.
Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		fundamentally alter marine littoral habitats, potentially decreasing the suitability of foraging habitats for adult char. This may occur through a number of specific stressors, including change in current and wave energy patterns, food web alterations and decreased	patterns, and wave energy and current patterns.	
Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and fitness, and potentially decreased survival due to predation exposure.		
Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding,	Permanent	Continuous				
Lacustrine		anchor trenching])						
Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles: Adults	in one or more of these parameters can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect juveniles and adult grow and fitness.
Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral habitats. Use of these habitats by adult char is limited, as these species tend to utilize cold, deepwater habitats in the photic and profundal zone. However, reduction in nearshore habitat productivity may affect abundance of	patterns, and wave energy and current patterns.	
Altered sediment supply]	Year-round	Permanent	Continuous]	potential prey species, reducing adult foraging		
Altered substrate composition		Year-round	Permanent	Continuous	potential proj species, reducing adult foruging			
Ecosystem Fragmentation	•				-			

			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Require assessment of the hydraulic effects of the project before permitting; avoid permittin designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	hydraulic effects of the project	See effects for related stressors under Water Quality Modificatio
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.
(Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off- channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density- dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	 hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or 	May affect survival, growth, and fitness at egg, alevin, and juvenile lif history stages. May affect adult survival and spawning productivity.
	Altered longitudinal habitat connectivity	Reduced availability of suitable habitats along longitudinal gradient.					<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. <u>Adults:</u> Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		
]	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u> : LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.

			Ez	xposure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity.
-	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
ſ	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
-	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile survival. May affect adult growth and spawning productivity.
Ī	Riverine and Lacustrine	•	·		·	•		·	·
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Char dependence on littoral lacustrine vegetation is relatively limited as this species tends to occupy cold water river habitats and deepwater lacustrine habitats in the photic or profundal zone where aquatic vegetation is limited or non-existent. Therefore, modification of aquatic vegetation may have limited direct effects on this species. However, such alterations may limit the productivity of prey species for native char, leading to decreased foraging opportunity and decreased growth and fitness.	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.

			Ex	posure					
r ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors unde Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growtl and fitness, as well as adult spawnin productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due towinter ice formation and scour.Juveniles:Altered growth and survivalcaused by temperatures outside optimalgrowth range and alteration of food webpatterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.

			Ex	posure					
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
	Marine		·	·					
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	<u>Adults and juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, adult char trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence have been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	<u>Adults and juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.

			Ex	posure	1	1			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Adults and juveniles</u> : Char dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, the dependence on terrestrial insect fall as a food source may be limited as adult char are primarily piscivorous. Indirect effects on food web productivity may decrease foraging opportunities, leading to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
]	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : Char dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from th impact mechanism are unknown.
]	Lacustrine		,			· · · ·			
i	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
]	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Char dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along the shoreline.	Effects of the action resulting from th impact mechanism are unknown.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification		-	-	-	-			
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.
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-			Ex	posure	Υ	·			
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
awn	ing Substrate Aug	mentation							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortalit injury limiting to survival.

7			Ex	posure		<u> </u>			Resulting Effects of the
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs and alevins, juveniles</u> : Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injur- egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short- term	Interannual-decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitn See effects for related stressors on a life-history stages under Water Qua Modification.
	Hydraulic and Geomorphic Modification								
	Riverine	Deduced as free heli's state	V	Short to any t	Continuou	L			Man affect inner 11 at 1
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning succ and overall population productivit
							availability of suitable migratory and spawning habitat.		

		1	Exposure					
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. <u>Juveniles</u> : Altered channel geometry, bank	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize adverse effects on channel geometry,	May affect survival at egg, alevin, a juvenile life-history stages. May af spawning productivity.
Altered substrate composition/stability			Short-term to long- term			stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	bank conditions, and substrate stability to the greatest extent practicable.	
Aquatic Vegetation						persist.		
Modification Riverine								
Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, grow and fitness.
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.		
						<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.		

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7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating and alevins. May affect juvenile growth and fitness and adult productivity and spawning succes
ha	nnel/Off-Channel Construction and Maintenance Activities	Habitat Creation/Modifie	cation						
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate	During project	Short-term	Interannual to	Juveniles	Potential migration delay, leading to reduced spawning productivity. Juveniles: Short-term reduction in foraging	Limit area of dewatering to the	May affect growth and fitness at
		abundance	construction and maintenance activities		decadal (depending on activity frequency)		opportunity, increased competition, decreased growth and fitness.	greatest extent practicable.	juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

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rity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification	•	•	-	2	-	÷	÷	÷
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
oaria	an Planting/Restor	ation Enhancement							
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Construction and Maintenance Activities							
Riverine , Lacustrine, Marine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Min spec assu spec

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ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins:Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness. Char dependence on littoral lacustrine vegetation is relatively limited as this species tends to occupy cold water river habitats and deepwater lacustrine habitats in the photic or profundal zone where aquatic vegetation is limited or non-existent. Therefore, modification of aquatic vegetation may have limited direct effects on this species in lacustrine environments.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitnes

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ctivity `ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Riparian Vegetation Modification		-	-	-	-						
	Riverine, Lacustrine, Marine											
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness			
	Water Quality Modification											
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u> : Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.			
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.			

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ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
etla	nd Creation Restor	ration/Enhancement							
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific nois disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pil driving) may lead to direct mortali injury limiting to survival.

Sub-			Ex	posure	_	_			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

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ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification		-	-	-				
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating en and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
ch	Nourishment/Cont	touring							
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Construction and Maintenance Activities									
Marine and Lacustrine									
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr water mach proje		
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoi produ comr		

			Ex	posure			-				
Mecl	chanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	aulic and orphic Modification			-	-	-		-			
Marine	e and Lacustrine										
Altered	d sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.		
	Aquatic Vegetation Modification										
Marine	ie										
product	d autochthonous ction d cover and habitat	Reduced foraging opportunities and rearing habitat availability Reduced cover	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.		
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.				
Lacust	Lacustrine										
Altered product	d autochthonous ction	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	Adults and juveniles: Char dependence on littoral lacustrine vegetation is relatively limited as this species tends to occupy cold water river habitats and deepwater lacustrine	<u>Design</u> : Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. <u>Construction</u> :	May affect growth and fitness of juveniles and adults. Reduced adu fitness may lead to decreased spawning success.		
Altered	d cover and habitat	Reduced cover					habitats in the photic or profundal zone where aquatic vegetation is limited or non-existent. Therefore, modification of aquatic vegetation may have limited direct effects on this species. However, such alterations may limit the productivity of prey species for native char, leading to decreased foraging opportunity and decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	spawning success.		
Water Modifie	· Quality ïcation										
Altered	d suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating e and alevins. May affect juvenile growth and fitness and adult productivity and spawning success		

ıb-			Ex	posure						
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.	
leef (Creation/Restoration	n/Enhancement								
	Construction and Maintenance Activities									
	Marine and Lacustrine									
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure Should exposure occur, direct mortality or injury is probable.	
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.	
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.	

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification							-	
	Marine								
	suitability; reduced food web complexity, habitat availability, and suitability	complexity, habitat availability, and	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally ofter marine litteral habitate	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift	May affect juvenile and adult survival and growth.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		fundamentally alter marine littoral habitats, potentially decreasing the suitability of foraging habitats for adult char. This may occur through a number of specific stressors, including change in current and wave energy patterns, food web alterations and decreased foraging opportunity, and increased	patterns, and wave energy and current patterns.	
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		competition for suitable habitats. The combined effect of these stressors can result in decreased growth and fitness, and potentially decreased survival due to predation exposure.		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

•.			Exj	posure	1	- r						
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	Lacustrine	·	·	·	·		·					
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Caref design impac projec design sedim				
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous		fundamentally alter lacustrine littoral habitats. Use of these habitats by adult char is limited, as these species tend to utilize cold, deepwater habitats in the photic and profundal zone. However, reduction in nearshore habitat productivity may affect abundance of	patter patter				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		potential prey species, reducing adult foraging opportunity and leading to decreased growth and fitness.					
	Altered sediment supply		Year-round	Permanent	Continuous							
]	Altered substrate composition		Year-round	Permanent	Continuous							
	Ecosystem Fragmentation											
	Marine		-	-			-					
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid proxi corric preda				
ĺ	Lacustrine											
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid proxin corrid predat				
	Aquatic Vegetation Modification											
	Marine											
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web preductivity.	Avoic veget				
	Lacustrine to decreased food web productivity.											
F	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent	Continuous	Juveniles;	<u>Adults and juveniles</u> : Char dependence on littoral lacustrine vegetation is relatively	Desig footp				

Minimization Measures	Resulting Effects of the Submechanism
Parefully evaluate project siting and esign and consider the magnitude of npact mechanisms produced by the roject. Encourage selection of project esigns that minimize effects on ediment supply, longshore drift atterns, and wave energy and current atterns.	May affect juveniles and adult growth and fitness.
woid placement of reef projects in roximity to juvenile migratory orridors, such that increased redation exposure may occur.	May affect juvenile survival, growth and fitness.
void placement of reef projects in roximity to juvenile migratory orridors, such that increased redation exposure may occur.	May affect juvenile survival, growth and fitness.
woid/minimize disturbance of aquatic egetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
Design: Limit project structural potprint to minimize shading of	May affect growth and fitness of juveniles and adults. Reduced adult

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered cover and habitat			(dependent on nature of activity)		Adults	limited as this species tends to occupy cold water river habitats and deepwater lacustrine habitats in the photic or profundal zone where aquatic vegetation is limited or non-existent. Therefore, modification of aquatic vegetation may have limited direct effects on this species. However, such alterations may limit the productivity of prey species for native char, leading to decreased foraging opportunity and decreased growth and fitness.	aqua exte Avc aqua cons
	Water Quality Modification							
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Care desig impa proje desig sedin patte
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use

Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement

Construction and Maintenance Activities												
Marine												
Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adh wor					

Resulting Effects of the Submechanism fitness may lead to decreased spawning success.
May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
May affect survival, growth, and fitness of juveniles and adults.
May cause temporary behavioral avoidance and displacement.

Sub-			Ex	posure	_				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

)-			Ex	posure					
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
ave	r Dam Removal								
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of larvae in impoundment areas. <u>Adults and juveniles</u> : Mortality, injury, or stress from stranding or entrainment in dewatering flows. <u>Juveniles</u> : Increased competition following displacement, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality juveniles and adults. Stress may affe survival, growth and fitness, and adu spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-10. HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

			Ex	posure								
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Hydraulic and Geomorphic Modification		-	-	-	-		-	-			
	Riverine											
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs-larvae Juveniles Adults	Eggs-larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and	arefully evaluate project siting nd design and consider the nagnitude of impact mechanisms roduced by the project. ncourage selection of project	May affect survival and productivity at egg, larvae, and juvenile life-history stages. May affect spawning productivity.			
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		survival. Pygmy whitefish dependence on groundwater inflow for incubation success is currently a data gap. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition	designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal		can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging					
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous		 complexity. This may mult foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of spawning areas) if potential spawning habitat is affected 					
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous							
	Ecosystem Fragmentation											
-	Riverine	1	1		1		T	Γ				
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen Decreased dissolved oxygen from	Year-round (most pronounced in summer and autumn when vegetation growth and decay is	Permanent	Seasonal	Eggs and larvae	Eggs and larvae: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressor under Water Quality Modifica			
		eutrophication below the impoundment (caused by elevated nutrient export)	most extensive)									
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, a fitness of juveniles and adults			

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Table A-10 (continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

)-			Ex	posure					
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities	Year-round	Permanent	Continuous	Larvae; Adults	Larvae and adults: Beaver dam removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect pygmy whitefish, which spawn in the mainstems of small,	Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	Stressor may affect larval and adult pygmy whitefish, but is unlikely to adversely affect these species.
		and rearing habitat availability					swift rivers and the larvae are transported to oligotrophic lakes for rearing to adulthood.		
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and adult spawning productivity
							resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		
	Riparian Vegetation Modification Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids	specific stressors to long-term prominent during (dependent or high flow conditions) required for	(dependent on time	Continuous to seasonal (dependent on specific stressor)	I Juveniles; ent on Adults	Eggs-larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during incubation, rearing, and spawning
		Spawning gravel sedimentation					Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous		turbidity, as described for related stressor responses under Water Quality Modification.		

-			Exj	posure					
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen E	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

Sub-			T	nosuro			
Sub- activity			EX	posure			
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor
Placen	Woody Debris nent/Movement/Reponstruction impacts	moval (for placement s apply)					
	Construction and Maintenance Activities						
	Riverine, Lacustrine						
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased areased

HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish. Table A-10 (continued).

growth and fitness.

Minimization Measures	Resulting Effects of the Submechanism
Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Sub-			Ex	posure		·			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae:Decreased incubation successdue to decreased dissolved oxygen asdescribed for related stressor responses underWater Quality Modification.Juveniles:Decreased refuge habitatavailability and foraging opportunities,leading to increased competition and resultingeffects on growth and fitness.Potentialhabitat avoidance and/or injury and mortalitycaused by excessive turbidity as described forrelated stressor responses under Water QualityModification.Adults:Decreased spawning success due todecreased availability of suitable spawninghabitat.Potential migration delay, habitatavoidance, and/or injury and mortality causedby excessive turbidity as described for relatedstressor responses under Water QualityModification.Modification.Modification.Adults:Potential migration delay, habitatavoidance, and/or injury and mortality causedby excessive turbidity as described for relatedstressor responses under Water QualityModification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Potential decreased eggincubation success and larvae survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Sub-			Ex	posure					
ictivity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. <u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
ļ	Riverine								
	Altered channel geometry Altered flow velocity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round Year-round (with stressor exposure occurring during	Permanent Permanent	Continuous Seasonal	Eggs-larvae Juveniles Adults	Eggs-larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Pygmy whitefish dependence on groundwater inflow for incubation success is currently a data gap.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the	May affect survival and productivity at egg, larvae, and juvenile life-history stages. May affect spawning productivity.
	Altered substrate composition Altered groundwater-	-	high-flow events, fall through spring) Year round Year-round (with	Permanent	Continuous	_	Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging	greatest extent practicable.	
	surface water exchange		stressor exposure occurring during egg incubation and juvenile rearing)		Continuous		opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning leagtions and/or ingenerated spawning		
							locations and/or increased scour and/or sedimentation of spawning areas) if potential spawning habitat is affected		

		Ex	posure	ή				
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Lacustrine				-				
Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind- driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival and productivity at juvenile life-his stage. Decreased adult fitness lead to reduced spawning productivity.
Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult whitefish. This may occur	sediment supply, longshore drift patterns, and wave energy and current patterns.	
Altered sediment supply		Year-round	Permanent	Continuous	through a number of specific stress including increased exertion and st	through a number of specific stressors, including increased exertion and stress		
Altered substrate composition		Year-round	Permanent	Continuous		due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable		
						habitats. The combined effect of these stressors can result in decreased growth, fitness, and productivity, as well as direct mortality.		
Ecosystem Fragmentation								
Riverine								
Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn	Permanent	Seasonal	Eggs and larvae	Eggs and larvae: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting	See effects for related stressor under Water Quality Modifica
		when vegetation growth and decay is most extensive)						
	Increased pollutant loading	growth and decay is	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		May affect survival, growth, an fitness of juveniles and adults.
Altered lateral (terrestrial/aquatic) habitat connectivity	Increased pollutant loading Reduced availability of off- channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	growth and decay is most extensive)	_	Continuous	Juveniles;		Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	

ub-			Ex	posure	Υ.	r							
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism				
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: LWD removal can fragment nearshore lacustrine habitats. Larval and juvenile pygmy whitefish are known to occur in these habitat types, but knowledge of dependence on these habitats is limited. Given prevalence in these habitat types, however, stressor exposure may affect juvenile survival, growth, and fitness if habitat access is impaired.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival, growth, and fitness.				
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.				
	Aquatic Vegetation Modification	Modification											
	Riverine and Lacustrine												
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitnes				
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.				
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.				

Table A-10 (continued).HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

			Exj	oosure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification		-	-	-	-	-		-
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs-larvae; Juveniles; Adults	Eggs-larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (optimal range 50°F or less). Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect larval, juvenile, and adult growth and fitness.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs-larvae:Decreased incubationsuccess due to decreased dissolvedoxygen as described for related stressorresponses under Water QualityModification.Juveniles:Decreased refuge habitatavailability and foraging opportunities,leading to increased competition andresulting effects on growth and fitness.Potential habitat avoidance and/or injuryand mortality caused by excessiveturbidity as described for related stressorresponses under Water QualityModification.Adults:Decreased spawning success dueto decreased availability of suitablespawning habitat.Potential migrationdelay, habitat avoidance, and/or injuryand mortality caused by excessiveturbidity, as described for related stressorresponses under Water QualityModification.Modification.Modification.Modification.delay, habitat avoidance, and/or injuryand mortality caused by excessiveturbidity, as described for related stressorresponses under Water QualityModification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during incubation, rearing, and spawning
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Decreased foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased pool availability and availability of suitable spawning habitat.	Encourage project designs that limit permanent alteration of high- quality habitat features.	May affect larval and juvenile survival, growth, and productivit May affect adult spawning productivity.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

)-			Exj	posure					
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults	Eggs-larvae: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs-larvae and adult spawning productivity.
	Lacustrine	·	·						•
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures). Pygmy whitefish depend on cold water of 50°F or less. Therefore, increased temperatures will limit suitable habitat.	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of currents, wind conditions, and other factors. However, juveniles trapped in habitats with isolated water level changes may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pygmy whitefish are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Whitefish dependence upon groundwater inflow is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.

•			Ez	posure	. <u></u>				
ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg and larvae. May affect juvenile survival, growth, and fitness, and ad survival and spawning productivity.
-	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
-	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect larvae development, juvenile survival, growth, and fitnes as well as adult survival, fitness, and spawning success.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

			Ex	posure		. <u>.</u>			
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
vni	ng Substrate Aug	mentation							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: Egg mortality due to membrane rupture. Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey. Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain. 	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Activity may cause direct mortality all life-history stages. May affect survival, growth, and fitness at all li history stages, depending on project specific noise intensity and receptor exposure.

 Table A-10 (continued).
 HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

			Ex	posure	1	1			Dogulting Efforts of the
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. Ma affect adult survival and spawning productivity.
							<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and larvae with limited motility are least likely to be present.	May cause direct mortality or injur egg, larvae, and juvenile life-histor stages. Injury and stress may affec survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitn See effects for related stressors on life-history stages under Water Qua Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning succ and overall population productivit

			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects) Altered substrate composition/stability	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term Short-term to long-term	Continuous	Eggs-larvae Juveniles Adults	Eggs-larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Pygmy whitefish dependence on groundwater inflow for incubation success is currently a data gap. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of spawning areas) if	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival and productivity at egg, larvae, and juvenile life-history stages. Ma affect spawning productivity.
	Aquatic Vegetation Modification						potential spawning habitat is affected		
	Riverine								
ŀ	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, grow and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due		

Sub-Exposure activity Туре **Mechanism of Impact** Stressor When Duration Frequency Life-history Form **Response to Stressor** Water Quality Modification Eggs and larvae: Turbidity sufficient to cause En Altered suspended solids Increased suspended solids Dependent on Temporary to short-Intermittent to Eggs and larvae; fine sediment embeddedness may lead to contributing term (dependent on interannual-decadal mi Juveniles; mechanism of impact direct mortality and decreased survival of contributing (dependent on to Adults eggs and larvae. mechanism of contributing sho mechanism of bac impact) Juveniles and adults: Responses vary impact) pra depending on stressor magnitude. Unavoidable extreme turbidity may cause pro physical injury and/or physiological effects turl (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success. In-Channel/Off-Channel Habitat Creation/Modification **Construction and Maintenance Activities** Riverine Elevated Hydrocarbons (associated During project Temporary to short-Interannual to Eggs and larvae; All life-history stages: Physiological Ret Equipment Operation with potential fuel and oil spills) construction activities term decadal responses to exposure at toxic levels, causing cor Juveniles; mortality or injury leading to reduced fitness. wa Adults Bioaccumulation of contaminants at subacute wo levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.

HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish. Table A-10 (continued).

	Resulting Effects of the
Minimization Measures	Submechanism
nsure project design avoids and/or inimizes habitat alterations leading ochronic bank instability. Avoid nort-term turbidity effects above ackground levels to greatest extent acticable. Adhere to established rotocols for managing sediment and rbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
efuel and service machinery in a ontrolled environment away from the ater body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: Egg mortality due to membrane rupture. Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey. Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decrease are limited; therefore, the effects of stressor exposure are uncertain. 	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Activity may cause direct mortality at all life-history stages. May affect survival, growth, and fitness at all life- history stages, depending on project- specific noise intensity and receptor exposure.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

			Ex	posure			-		
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Water Quality Modification Dependent on contributing mechanism of impact Temportary to short- trum (dependent on contributing Intermittent to interannual-decadal (dependent on contributing Eggs and larvae: Tuveniles; Adults Ensure project design avoids and/or minimizes habitat alterations leading is short-err turbidity effects about short-err turbidity effects about a contributing Ensure project design avoids and/or minimizes habitat alterations leading incehanism of impact) Eggs and larvae: Tuveniles; Adults Ensure project design avoids and/or minimizes habitat alterations leading is short-err turbidity effects about short-err turbidity, reduced for managing sediment and turbidity. Altered Pollutant Loading Elevated Hydrocarbons (associated During project Temporary to short- Internanual to Eggs and larvae; Haveniles; Adults Eggs and larvae; Haveniles; Adults Environ and and adults; Environ and turbidity may cause the havior physiological turbidity Environ and turbidity. Environ and turbidity.					-				
	Altered suspended solids	construction or if in-channel project	contributing	term (dependent on contributing mechanism of	interannual–decadal (dependent on contributing mechanism of	Juveniles;	fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and	minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and	May affect survival of incubating egg and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
-	Altered Pollutant Loading					Juveniles;	responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness.	controlled environment away from the water body. Limit heavy machinery	May affect survival, growth, and fitness of juveniles and adults.
aria	n Planting/Restor	ation Enhancement							
	Construction and Maintenance Activities								
	Riverine , Lacustrine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Direct mortality due towinter ice formation and scour.Juveniles:Altered growth and survivalcaused by temperatures outside optimalgrowth range and alteration of food webpatterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Riverine, Lacustrine								
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Direct mortality due towinter ice formation and scour.Juveniles:Altered growth and survivalcaused by temperatures outside optimalgrowth range and alteration of food webpatterns.Adults and juveniles:Direct mortality causedby exposure to temperatures in excess oftolerance thresholds.Adults:Decreased spawning fitness due tomigration delays caused by thermal barriers.	Min spec assu spec	

			Ех	posure					
rity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification Riverine, Lacustrine								
-	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitne

Table A-10 (continued).

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine, Lacustrine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures). Pygmy whitefish depend on cold water of 50°F or less. Therefore, increased temperatures will limit suitable habitat.	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Direct mortality due to winter ice formation and scour.Juveniles:Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns.Adults and juveniles:Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults:Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

			Ex	posure	I				
Mechanism o	of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
nd Creation	n Restora	ation/Enhancement							
Construction an Maintenance A									
Riverine									
Equipment Oper	ration	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: Egg mortality due to membrane rupture. Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey. Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain. 	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Activity may cause direct mortality a all life-history stages. May affect survival, growth, and fitness at all lif history stages, depending on project- specific noise intensity and receptor exposure.

 Table A-10 (continued).
 HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae:Decreased incubation successdue to decreased dissolved oxygen asdescribed for related stressor responses underWater Quality Modification.Juveniles:Decreased refuge habitatavailability and foraging opportunities,leading to increased competition and resultingeffects on growth and fitness. Potentialhabitat avoidance and/or injury and mortalitycaused by excessive turbidity as described forrelated stressor responses under Water QualityModification.Adults:Decreased spawning success due todecreased availability of suitable spawninghabitat.Potential migration delay, habitatavoidance, and/or injury and mortality causedby excessive turbidity as described for relatedstressor responses under Water QualityModification.Adults:Decreased spawning success due todecreased availability of suitable spawninghabitat.Potential migration delay, habitatavoidance, and/or injury and mortality causedby excessive turbidity as described for relatedstressor responses under Water QualityModification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

			Ex	posure					
rity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
ch	Nourishment/Cont	touring					·		
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Construction and Maintenance Activities										
Lacustrine										
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contre water mach projec			
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid produ comn			

Table A-10 (continued).HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

ty			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification		-	-	-	-			-
	Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover					survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	1	
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages:All affected life-history stages:Physiologicalresponses to exposure at toxic levels, causingmortality or injury leading to reduced fitness.Bioaccumulation of contaminants at subacutelevels, resulting in chronic physiologicaleffects leading to reduced fitness and/ormortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Sub-Exposure activity **Mechanism of Impact** Stressor When Duration Frequency Life-history Form **Response to Stressor** Туре **Reef Creation/Restoration/Enhancement Construction and Maintenance Activities** Lacustrine Equipment operation and Elevated noise, visual and physical During project Temporary (auditory Interannual to Juveniles; <u>All life-history stages</u>: Stressor response Av materials placement disturbance construction activities masking) to shortdecadal (during dependent on magnitude and duration of per Adults term (hearing project construction disturbance, and project-specific pre threshold effects) and maintenance) environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. Construction vessel Increased or altered ambient noise During project Temporary (auditory Interannual to Juveniles; Adults and juveniles: Auditory masking or Av decadal (during temporary hearing threshold effects may levels construction masking) to shortoperation Adults noi increase risk of predation and/or decrease term (hearing project construction) equ threshold effects) foraging efficiency due to decreased ability to tec sense predators and/or prey. Bank, channel, shoreline Localized alteration in invertebrate During project Short-term Interannual to Juveniles <u>Juveniles</u>: Short-term reduction in foraging Av disturbance abundance from burial, increased construction and decadal (depending opportunity, increased competition, decreased pro suspended sediment maintenance activities on activity growth and fitness. cor frequency)

 Table A-10 (continued).

Minimization Measures	Resulting Effects of the Submechanism
void construction activities during eriods when individuals may be resent, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
void/minimize cavitation to limit bise intensity. Promote use of vessels quipped with antinoise/antivibration chnology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
void project site which are roductive and have a healthy benthic ommunity.	May affect growth and fitness at juvenile life-history stage.

			Exj	posure	r				
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
]	Lacustrine		1		r	-			
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind- driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	y, and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns uvenile ccur essors, stress ve energy posure	May affect survival and productivity at juvenile life-histo stage. Decreased adult fitness m lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous		or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult whitefish. This may occur through a number of specific stressors,		
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep		
	Altered sediment supply		Year-round	Permanent	Continuous		water habitat, food web alterations and decreased foraging opportunity, and		
	Altered substrate composition		Year-round	Permanent	Continuous		increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, fitness, and productivity, as well as direct mortality.		
j	Ecosystem Fragmentation								
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, gr and fitness.
	Aquatic Vegetation Modification								
1	Lacustrine		1		T	-1		1	
1	Altered autochthonous production Altered cover and habitat	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, gr and fitness.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

b-			E	xposure					
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults:Responses varydepending on stressor magnitude.Unavoidable extreme turbidity may causephysical injury and/or physiological effects(e.g., gill trauma, altered osmoregulation,blood chemistry changes).Moderate to highturbidity may cause behavioral alteration (e.g.,avoidance responses) leading to increasedterritoriality, reduced foraging opportunity,increased predation exposure, and alteredmigration behavior.Adults:Reduction in suitable spawninghabitat (due to substrate embeddedness) andreduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating ea and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.

Not applicable

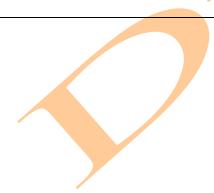


Table A-10 (continued).

Sub-			Ex	posure			_		
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
eave	r Dam Removal								
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modifications.

Table A-11. HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

			Ex	posure										
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism					
	Hydraulic and Geomorphic Modification													
	Riverine													
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and larvae; Juveniles Adults	<u>All exposed life history stages</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival, growth, and fitness at all life history stages, spawning productivity. May affect distribution and abundance.					
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		Mudminnow are dependent on habitats with low or zero flow velocity, loose silt substrate, and abundant aquatic vegetation for survival. Any alterations in hydraulic and geomorphic conditions	designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.						
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal		that affect flow and substrate characteristics are likely to affect habitat suitability for this species. This in turn is							
	Altered substrate composition (including spawning gravel sedimentation) Altered groundwater- surface water exchange		Year round	Intermediate-term to long-term	Continuous		likely to affect survival, growth, and fitness at all life history stages, spawning productivity, and distribution and abundance.							
			Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous									
Ì	Ecosystem Fragmentation													
ľ	Riverine													
-	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased hyporheic exchange in downstream reaches may lead to decreased incubation success (i.e., decreased survival) due to decreased intragravel DO levels. <u>Adults and juveniles</u> : Decreased availability of thermal refuge habitat provided by groundwater upwelling may lead to decreased survival, growth, and fitness. <u>Adults</u> : Decreased availability of desirable grouning sites (due to leak of	Avoid draining impounded area through use of beaver deceivers.	May affect egg and larvae survival, may affect juvenile survival, growth, and fitness. M affect adult survival and spawnin productivity.					
		Increased pollutant loading	Year-round	Long-term to	Continuous	Eggs and larvae;	desirable spawning sites (due to lack of groundwater induced upwelling) may lead to decreased spawning productivity.All exposed life-history stages:	Avoid draining impounded area	May affect survival, growth, and					
		increased ponutant loading	i ear-round	permanent	Conunuous	Eggs and larvae; Juveniles; Adults	All exposed life-nistory stages: See related stressor responses under Water Quality Modification.	through use of beaver deceivers.	fitness of juveniles and adults.					

			posure						
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Larvae; Adults	Larvae and adults: Beaver dam removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. Reduced organic matter input and terrestrially derived prey may lead to	Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
		Reduced foraging opportunities and rearing habitat availability					decreased survival, growth, and fitness.	haonat.	
	Aquatic Vegetation Modification								
1	Riverine								
-	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles, Adults: Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival, growth, and fitness of juveniles. This is particularly true for mudminnow, which are dependent on aquatic vegetation for habitat.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile and adult survival, growth, and fitness. May affect spawning productivity, abundance and distribution.
	Riverine Altered stream bank and	Increased suspended solids	Year-round (with	Intermediate-term	Continuous to	Eggs and larvae;	Eggs/larvae: Decreased incubation	Avoid/minimize disturbance of	May affect survival, growth, and
	Anered stream bank and shoreline stability	Spawning gravel sedimentation	rear-round (with specific stressors prominent during high flow conditions)	to long-term (dependent on time required for riparian recovery)	seasonal (dependent on specific stressor)	Juveniles; Adults	Eggs/larvae:Decreased includationsuccess due to decreased dissolvedoxygen as described for related stressorresponses under Water QualityModification.Juveniles:Decreased refuge habitatavailability and foraging opportunities,leading to increased competition andresulting effects on growth and fitness.Potential habitat avoidance and/or injuryand mortality caused by excessiveturbidity, as described for related stressorresponses under Water QualityModification.Adults:Decreased spawning success dueto decreased availability of suitablespawning habitat.Potential migrationdelay, habitat avoidance, and/or injuryand mortality caused by excessiveturbidity, as described for related stressorresponses under Water QualityModification.Modification.Modification.Modification.Modification.	Avoid/Infinitize distributice of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-11	(continued)
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HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow. **l).**

-			Ex	posure	1	1			
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile rearing.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults:</u> Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Behavioral alteration resulting in increased predation exposure (mudminnows are tolerant of wide variations in DO levels due to the ability to absorb atmospheric oxygen).	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect egg and larval survival. May affect juvenile and adult behavior.

			Exj	posure	η	1			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
mei ons	Voody Debris nt/Movement/Re struction impacts	moval (for placement s apply)							
N	Maintenance Activities								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noiss disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pil driving) may lead to direct mortali injury limiting to survival.

Sub-			Ex	posure	1	Υ.			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modifications.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.

ub-			Ex	posure					
tivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Potential decreased eggincubation success and larvae survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification Riverine								
-	Altered channel geometry Altered flow velocity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round Year-round (with stressor exposure occurring during high-flow events, fall	Permanent Permanent	Continuous Seasonal	Eggs and larvae; Juveniles Adults	All exposed life history stages: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. Mudminnow are dependent on habitats with low or zero flow velocity, loose silt substrate, and abundant aquatic vegetation for survival. Any alterations	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the	May affect survival, growth, and fitness at all life history stages, spawning productivity. May affect distribution and abundance.
	Altered substrate composition	_	through spring) Year round	Permanent	Continuous	_	in hydraulic and geomorphic conditions that affect flow and substrate characteristics are likely to affect habitat suitability for this species. This in turn is	greatest extent practicable.	
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		likely to affect survival, growth, and fitness at all life history stages, spawning productivity, and distribution and abundance.		

HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-			Ex	posure							
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Lacustrine	-					-				
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind- driven waves are most pronounced)	Permanent	Continuous	Eggs and larvae; Juveniles Adults	<u>All exposed life history stages</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. Mudminnow are dependent on habitats	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival, growth, and fitness at all life history stages, spawning productivity. May affect distribution and abundance.		
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		with low or zero flow velocity, loose silt substrate, and abundant aquatic vegetation for survival. Any alterations in hydraulic and geomorphic conditions that affect flow and substrate	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.			
	Altered sediment supply		Year-round	Permanent	Continuous		characteristics are likely to affect habitat suitability for this species. This in turn is				
	Altered substrate composition		Year-round	Permanent	Continuous		likely to affect survival, growth, and fitness at all life history stages, spawning productivity, and distribution and abundance.				
	Ecosystem Fragmentation										
	Riverine										
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Decreased hyporheicexchange in downstream reaches maylead to decreased incubation success (i.e.,decreased survival) due to decreasedintragravel DO levels.Adults and juveniles:Decreasedavailability of thermal refuge habitatprovided by groundwater upwelling maylead to decreased survival, growth, andfitness.Adults:Decreased availability ofdesirable spawning sites (due to lack ofgroundwater induced upwelling) maylead to decreased spawning productivity.	Require assessment of the hydraulic effects of the project before permitting	May affect egg and larvae survival, may affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.		
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.		

Table A-11	(continued)
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HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow. **l).**

			Ex	posure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off- channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and larvae; Juveniles; Adults	Larvae and adults: LWD removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. Reduced organic matter input and terrestrially derived prey may lead to decreased survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered longitudinal habitat connectivity	Reduced availability of suitable habitats along longitudinal gradient.							
ľ	Lacustrine				I				I
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: LWD removal can fragment nearshore lacustrine habitats. Olympic Mudminnow are known to occur in these habitat types. Consequently, stressor exposure may affect survival, growth, and fitness if habitat access is impaired.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival, growth, and fitness.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	Juveniles: See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification						• •		
- [Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. This is particularly true for mudminnow, which are dependent on aquatic vegetation for habitat.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile and adult survival, growth, and fitness. May affect spawning productivity, abundance and distribution.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors unde Water Quality Modification.

ty			Exj	posure					
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification		-	-	-	-		-	-
	Riverine				-				
input and a	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles and adults: This species has a wide temperature tolerance range. May result in behavioral alteration.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult behavior.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.		
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Decreased foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased pool availability and availability of suitable spawning habitat.	Encourage project designs that limit permanent alteration of high- quality habitat features.	May affect larval and juvenile survival, growth, and productivity May affect adult spawning productivity.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults	Eggs-larvae: Decreased incubation success. <u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs-larva and adult spawning productivity.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

ub- ctivity			Ex	posure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles and adults: This species has a wide temperature tolerance range. May result in behavioral alteration.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult behavior.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile rearing.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness. <u>Adults</u> : Increased mortality, decreased fitness, and spawning success due to decreased availability of suitable spawning and rearing habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased incubation success. Juveniles: Decreased availability of thermal refuge habitat, resulting in increased thermal stress, increased competition for suitable habitats. <u>Adults</u> : Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along shoreline.	May affect survival of eggs an larvae. May affect juvenile survival and growth. May affe adult spawning productivity.

b-			Ex	posure	Ť	Υ			
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Behavioral alteration resulting in increased predation exposure (mudminnows are tolerant of wide variations in DO levels due to the ability to absorb atmospheric oxygen).	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect egg and larval surviva May affect juvenile and adult behavior.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-			Ex	posure	1	1		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Spawn	ning Substrate Aug	mentation						
	Not applicable.							
In-Cha	annel/Off-Channel	Habitat Creation/Modified	cation					
	Construction and Maintenance Activities							
	Riverine							
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	R co w w
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: Egg mortality due to membrane rupture. Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey. Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain. 	L pr w li
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	A ri sl p

Minimization Measures	Resulting Effects of the Submechanism
efuel and service machinery in a ontrolled environment away from the ater body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of juveniles and adults.
imit in-water equipment use where racticable. Adhere to in-water work indows to avoid effects on multiple fe history stages where possible.	Activity may cause direct mortality at all life-history stages. May affect survival, growth, and fitness at all life- history stages, depending on project- specific noise intensity and receptor exposure.
void/minimize disturbance of parian vegetation. Limit bank, noreline and benthic disturbance. Use roper erosion control BMPs.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure			_		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Potential decreased eggincubation success and larvae survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Mortality or injury from entrainment.Juveniles:Decreased foraging opportunity due to short-term reduction in prey abundance.Decreased growth and fitness.All life-history stages:See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

			Ex	posure					
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification		-		-	-			
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
							<u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.		
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
hari	an Planting/Restor	ation Enhancement							
	Construction and Maintenance Activities								
	Riverine , Lacustrine		-				-		
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : This species has a wide temperature tolerance range. May result in behavioral alteration.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile and adult behavior.

HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Working Draft–Do Not Cite Habitat Modification

Table A-11	(continued)
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Utivity type Mechanism of Impact Stressor When Duration Frequency Life-history Form Response to Stressor Minimized intrubution Measure seasonal (dependent on time renoval of invasive riparian species prominent during high now conditions) Increased suspended solids - due to specific stressors prominent during high now conditions) Short-term to intermediate (dependent on time recovery) Eggs and larvae; on specific stressor Eggs and larvae; Juveniles; Adults Eggs and larvae; described for related stressor spenses under variability and foraging opportunities, leave to decreased benthic dissolved oxygen as described for related stressor responses under variability and foraging opportunities, leave to decreased benthic dissolved oxygen as availability and foraging opportunities, leave to decreased benthic dissolved oxygen as described for related stressor responses under variability and foraging opportunities, leave to decreased benthic dissolved oxygen as described for related stressor responses under variability and foraging opportunities, leave to decrease and or injury and mortality Minimize disturbance during in specific stressor Image: Describe the distribution of the specific stressor in the specific str	nvasive May affect survival, growth, and iate fitness during juvenile rearing. M
removal of invasive riparian species specific stressors prominent during high flow conditions) intermediate (dependent on time recovery) intermediate (dependent on tintermediate (dependent on time r	iate fitness during juvenile rearing. M ring and affect adult survival and spawning
Aquatic Vegetation Modification	
Riverine, Lacustrine	
Altered autochthonous productionDecreased productivity (locally due to increased shading)Year-round (most pronunced in spring and summer when vegetation growth is most extensive)PermanentContinuousJuveniles; AdultsJuveniles; adults: Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. This is particularly true for mudminnow, which are dependent on aquatic vegetation for habitat.Design riparian patches with ve canopy coverage so that sunlig continue to reach the channel.	

Sub-			Exj	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification			-		-	-	-	
	Riverine, Lacustrine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. This is particularly true for mudminnow, which are dependent on aquatic vegetation for habitat.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile and adult growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : This species has a wide temperature tolerance range. May result in behavioral alteration.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile and adult behavior.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

v			Ex	posure	1	Υ	4		Resulting Effects of the
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
an	d Creation Restor	ation/Enhancement							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: Egg mortality due to membrane rupture. Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey. Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain. 	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Activity may cause direct mortalit all life-history stages. May affect survival, growth, and fitness at all history stages, depending on proje specific noise intensity and recepte exposure.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased benthic dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

b-			Ex	posure			_		
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification			-					
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
							<u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.		
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
each	Nourishment/Cont	ouring							
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of all life history stages.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All affected life-history stages</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect survival, growth, and fitness of all life history stages.

Construction and Maintenance Activities												
Lacustrine												
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr water mach proje					
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All affected life-history stages</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoi produ comr					

Sub-Exposure activity **Mechanism of Impact** Stressor When Duration Frequency Life-history Form **Response to Stressor** Туре Hvdraulic and **Geomorphic Modification** Lacustrine Localized alteration in invertebrate Short-term - long-Interannual to Eggs and larvae; All affected life-history stages: Short-term Altered sediment supply During project abundance from burial construction and decadal (depending reduction in foraging opportunity, increased term Juveniles; maintenance activities competition, decreased growth and fitness. on activity Adults frequency) Aquatic Vegetation Modification Lacustrine Juveniles and adults: Extensive Altered autochthonous Reduced foraging opportunities and Year-round Short-term to long-Continuous Juveniles; modification of aquatic vegetation can rearing habitat availability term(dependent on production Adults alter habitat complexity and food web nature of activity) productivity, which may in turn affect Altered cover and habitat Reduced cover survival growth, and fitness of juveniles. This is particularly true for mudminnow, which are dependent on aquatic vegetation for habitat. Water Quality Modification Altered suspended solids Increased suspended solids During construction Temporary to short-Intermittent to Eggs and larvae; Eggs and larvae: Turbidity sufficient to and during subsequent term (dependent on interannual-decadal cause fine sediment embeddedness may Juveniles; high energy periods grain size of (dependent on lead to decreased survival of eggs and Adults augmented sediment) contributing larvae. mechanism of Juveniles and adults: Responses vary impact) depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success. All affected life-history stages: Physiological Altered Pollutant Loading Elevated Hydrocarbons (associated During project Temporary to short-Interannual to Juveniles: with potential fuel and oil spills) construction activities term (dependent on decadal responses to exposure at toxic levels, causing Adults mortality or injury leading to reduced fitness. contributing mechanism of Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological impact)

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

effects leading to reduced fitness and/or

mortality.

Minimization Measures	Resulting Effects of the Submechanism
Avoid project site which are productive and have a healthy benthic community.	May affect survival, growth, and fitness of all life history stages.
Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile and adult survival, growth, and fitness. May affect spawning productivity, abundance and distribution.
Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

•.			Ex	posure	T.	<u></u>			
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
ef C	Creation/Restoration	n/Enhancement							
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane. Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life- history stages, depending on project-specific noise intensity a receptor exposure. May cause direct mortality or injury.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

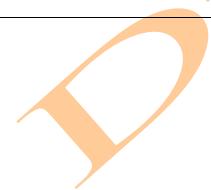
nanism of Impact Ilic and rphic Modification rine I wave energy period waves) current velocities nearshore ion patterns	Stressor Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	When Year-round (with predominant effects from fall through spring when wind- driven waves are most pronounced) Year-round (with effects more predominant in reservoirs versus natural lakes) Year-round (with variable effects by	Duration Permanent Permanent Permanent	Frequency Continuous Continuous Seasonal	Life-history Form Juveniles; Adults	Response to Stressor	Minimization Measures Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns	Resulting Effects of the Submechanism May affect survival and productivity at juvenile life-his stage. Decreased adult fitness lead to reduced spawning productivity.
rphic Modification rine d wave energy period waves) current velocities nearshore	habitat suitability; reduced food web complexity, habitat	predominant effects from fall through spring when wind- driven waves are most pronounced) Year-round (with effects more predominant in reservoirs versus natural lakes) Year-round (with variable effects by	Permanent	Continuous	,	current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult Olympic Mudminnow. This may occur through a number of specific	and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and	productivity at juvenile life-hi stage. Decreased adult fitness lead to reduced spawning
l wave energy period waves) current velocities nearshore	habitat suitability; reduced food web complexity, habitat	predominant effects from fall through spring when wind- driven waves are most pronounced) Year-round (with effects more predominant in reservoirs versus natural lakes) Year-round (with variable effects by	Permanent	Continuous	,	current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult Olympic Mudminnow. This may occur through a number of specific	and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and	productivity at juvenile life-h stage. Decreased adult fitnes lead to reduced spawning
period waves) current velocities nearshore	habitat suitability; reduced food web complexity, habitat	predominant effects from fall through spring when wind- driven waves are most pronounced) Year-round (with effects more predominant in reservoirs versus natural lakes) Year-round (with variable effects by	Permanent	Continuous	,	current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult Olympic Mudminnow. This may occur through a number of specific	and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and	productivity at juvenile life-h stage. Decreased adult fitnes lead to reduced spawning
nearshore		effects more predominant in reservoirs versus natural lakes) Year-round (with variable effects by				fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult Olympic Mudminnow. This may occur through a number of specific	patterns, and wave energy and	
		variable effects by	Permanent	Seasonal		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult Olympic Mudminnow. This may occur through a number of specific stressors, including increased exertion		
		season [e.g., circulation patterns])				stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or		
sediment supply		Year-round	Permanent	Continuous		exposure to deep water habitat, food web		
substrate ition		Year-round	Permanent	Continuous		opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, fitness, and	ncreased competition ts. The combined essors can result in , fitness, and	
tem Fragmentation	·							
rine								
cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, gr and fitness.
c Vegetation cation								
rine		r		F				
autochthonous ion cover and habitat	Localized reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, gr and fitness.
sit it c c c c c q	em Fragmentation ine cover and habitat Vegetation ation ine autochthonous on	substrate ion em Fragmentation ine cover and habitat Increased predation by piscivorous fish Vegetation ation ine autochthonous Localized reduced foraging opportunities cover and habitat	substrate Year-round substrate Year-round em Fragmentation Increased predation by piscivorous fish scover and habitat Increased predation by piscivorous fish Vegetation ation Vegetation autochthonous on Localized reduced foraging opportunities cover and habitat Localized reduced foraging opportunities Quality Vear-round	substrate Year-round Permanent substrate Year-round Permanent em Fragmentation ine Permanent cover and habitat Increased predation by piscivorous fish Year-round Permanent Vegetation ation Increased predation by piscivorous fish Year-round Permanent utochthonous on Localized reduced foraging opportunities Year-round Short-term to permanent (dependent on nature of activity) Quality Duality Short-term to permanent (dependent on nature of activity)	Substrate Year-round Permanent Continuous em Fragmentation Increased predation by piscivorous fish Year-round Permanent Continuous scover and habitat Increased predation by piscivorous fish Year-round Permanent Continuous Vegetation attom Increased predation by piscivorous fish Year-round Permanent Continuous vine Increased predation do predation by piscivorous fish Year-round Short-term to permanent (dependent on nature of activity) Continuous on Increased foraging opportunities Year-round Short-term to permanent (dependent on nature of activity) Continuous patity Deality Short-term to permanent (dependent on nature of activity) Continuous	Notion Year-round Permanent Continuous wubstrate Year-round Permanent Continuous em Fragmentation Increased predation by piscivorous fish Year-round Permanent Continuous sover and habitat Increased predation by piscivorous fish Year-round Permanent Continuous Juveniles Vegetation attom Localized reduced foraging opportunities Year-round Short-term to permanent (dependent on nature of activity) Continuous Juveniles; wubstrate opportunities Year-round Short-term to permanent (dependent on nature of activity) Localized reduced foraging opportunities Short-term to permanent (dependent on nature of activity) Continuous Juveniles; wubstrate Opportunities Year-round Short-term to permanent (dependent on nature of activity) Continuous Juveniles; wubstrate Opportunities Year-round Short-term to permanent (dependent on nature of activity) Continuous Juveniles;	ubstrate Year-round Permanent Continuous alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, fitness, and productivity, as well as direct mortality. am Fragmentation Increased predation by piscivorous fish Year-round Permanent Continuous Juveniles Juveniles Juveniles Decreased growth and fitness. sover and habitat Increased predation by piscivorous fish Year-round Permanent Continuous Juveniles Juveniles Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation exposure. Increased predation by piscivorous fish vegetation ation Increased reduced foraging Year-round Short-term to permanent (dependent on nature of activity) Juveniles; Juveniles; Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. sover and habitat Localized reduced foraging opportunities, leading to increased competition and resulting of activity) Short-term to permanent (dependent on nature of activity) Juveniles; Juveniles; becre	Aubstrate tion Year-round Permanent Continuous alterations and decreased forging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, filtness, and productivity, as well as direct mortality. Immem Fragmentation immem Fragmentation immem Fragmentation immem Fragmentation immem Fragmentation increased predation by piscivorous fish Year-round Permanent Continuous Juveniles Decreased stress (from predation exposure. Increased stress (from predation avoidance) leading to decreased predation exposure. Increased stress (from predation exposure. Increased stress (from predation exposure. Increased stress (from predation exposure. Increased stress (from predation exposure many occur. Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure. Increased stress (from predation exposure. Increased stress (from predation exposure many occur. Avoid predation exposure many occur. Vegetation ation Localized reduced foraging opportunities Short-term to permanent (dependent on nature of activity) Juveniles: Juveniles: Inveniles: Inveniles: Perceased competition and resulting evegtation during project construction. numbem Localized reduced foraging opportunities Short-term to permanent (dependent on nature of activity) Continuous <t< td=""></t<>

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-			Ех	posure					
activity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eg and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>All affected life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.

HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Not applicable



			Ex	posure		· · · · · · · · · · · · · · · · · · ·	4		
Ÿ	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
ver	Dam Removal								
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growt and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: Egg mortality due to membrane rupture. Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey. Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain. 	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Activity may cause direct mortality a all life-history stages. May affect survival, growth, and fitness at all lif history stages, depending on project- specific noise intensity and receptor exposure.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs:Mortality, injury, or stress from increased flow entrainment as impoundment dewatering.Adults and juveniles:Mortality, injury, or stress from stranding or entrainment in dewatering flows.Juveniles:Increased competition following displacement, reduced growth and fitness, and increased predation exposure.Adults:Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality juveniles and adults. Stress may aff survival, growth and fitness, and adu spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.

			Ex	posure		-			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors unde Water Quality Modification.
	Hydraulic and Geomorphic Modification								
_	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival, growth, and fitness at egg and juvenile life- history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. Dace are associated with	designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal		low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading		
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous		to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous		corridor and a reduction of the highetory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations, egg burial, etc.) if potential spawning habitat is affected.		
	Ecosystem Fragmentation								
	Riverine		1					1	
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs	Eggs and larvae: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Stressor Reduced recruitment of	When	Duration	Frequency	Life-history Form	Response to Stressor
Reduced recruitment of					F
terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Permanent	Continuous	Eggs (dace); Juveniles; Adults	Eggs: Adult dace spawning habitat availability may be limited by lateral disconnection. Increased egg density may in turn increase potential egg losses from predation, localized water quality impacts, or other mechanisms, limiting egg survival and/or incubation success. Juveniles: Disconnection of floodplain habitats can lead to decreased availability and suitability of rearing habitat, and changes in food web complexity. Moderate gradient stream systems preferred by sculpins may limit the extent of suitable habitat area. Disconnection of sloughs and similar slow-flowing floodplain habitats in lower gradient systems may limit habitat area preferred by dace and juvenile suckers. These stressors may thereby result in decreased foraging opportunities and increased competition for suitable habitats, affecting survival, growth, and fitness. Adults: Disconnection of sloughs and similar slow-water rearing habitats may limit the availability of suitable foraging and spawning habitat for dace. In moderate gradient habitats, disconnection of floodplain habitats may limit the availability and suitability of spawning habitat for mountain sucker, and foraging and spawning habitat for margined sculpins. These stressors may thereby result in decreased foraging opportunities, and increased competition for suitable habitats, affecting survival, growth, fitness, and by extension, spawning productivity.
reduced foraging opportunity,	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Decreased refuge habitat availability and foraging opportunities,
reduction in available cover					leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.
	productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced foraging opportunity Reduced food web productivity, reduced foraging opportunity,	productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Image: state sta	Productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Image: state of the s	Productivity due to reduction of organic matter inputs Reduced foraging opportunities; and rearing habitat availability Reduced foraging opportunities; reduced foraging opportunity, Year-round Permanent Continuous Juveniles; Adults

Minimization Measures	Resulting Effects of the Submechanism
equire assessment of the rdraulic effects of the project fore permitting and avoid ermitting designs that lead to sconnection of floodplain ibitat.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. May affect adult spawning productivity.
void draining impounded area rough use of beaver deceivers.	May affect survival, growth, and productivity of juvenile and adult life- history stages.

Table A-12 (continued).	HPA HCP Habitat Modification I	Exposure and Response Mat	rix for Umatilla Dace, Leopar	d Dace, Lake Chub, Margined
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			Exj	posure					
t y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Decreased incubation success due to turbidity effects as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Dace feed on terrestrial insects. While less dependent, suckers are opportunistic feeders dependent on overall food web productivity. Reduced allochthonous inputs may affect food web productivity, leading to decreased foraging opportunities and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness at juvenile and adult life-history stages.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification

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ed Sculpin, and Mountain Sucker.

Sub-			Ex	posure	.	.		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensu mini to ch shor back prac proto turb
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu envi area com
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limi Repl nativ inva Avo throu

Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)

Construction and Maintenance Activities											
Riverine, Lacustrine											
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contr water work				

Minimization Measures	Resulting Effects of the Submechanism
asure project design avoids and/or inimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and rbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
efuel machinery in a controlled vironment away from the project ea. Avoid reducing hydraulic mplexity.	May affect survival, growth, and fitness of juveniles and adults.
mit damage to riparian area. eplant former impoundment with tive vegetation to discourage vasives and stabilize sediments. void draining impounded area rough use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
efuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Ex	posure		1			
activity Type N	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs, Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: Egg mortality due to membrane rupture. Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey. Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decrease are limited; therefore, the effects of stressor exposure are uncertain. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality at all life-history stages. May affect survival, growth, and fitness at all life- history stages, depending on project- specific noise intensity and receptor exposure.

Sub- activity			Exp	osure	i	1			
nty e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	<u>Eggs/larvae:</u> Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
							<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
							<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality and inju May affect survival, growth, and fitness at juvenile and adult life-hist stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	<u>Eggs and juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injur
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. <u>Juveniles and adults</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Qual Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect juvenile and adult grow and fitness.

Sub-			Exp	posure		_			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival, growth, and fitness at egg and juvenile life- history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. Dace are associated with	designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition		Year round	Permanent	Continuous		low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading		
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations, egg burial, etc.) if potential spawning habitat is affected.		



			Ex	posure					
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine	-					-		
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind- driven waves are most pronounced)	Permanent	Continuous	Eggs (dace); Juveniles; Adults	<u>All exposed life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	and design and consider the fitness a fitness a stages.	May affect survival, growth, and fitness at all exposed life-history stages. Decreased fitness may le to reduced spawning productivity
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		fundamentally alter lacustrine littoral p		
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous	0			
	Ecosystem Fragmentation								
	Riverine		- F						
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and larvae	Eggs and larvae: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting	See effects for related stressors under Water Quality Modificatio
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker. Table A-12 (continued).

			Ex	posure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off- channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs (dace); Juveniles; Adults	Eggs: Adult dace spawning habitat availability may be limited by lateral disconnection, and by limitations on movement in the nearshore zone. Increased egg density may in turn increase potential egg losses from predation, localized water quality impacts, or other mechanisms, limiting egg survival and/or incubation success.	Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	May affect egg survival. May affect juvenile and adult surviv growth, and fitness. May affec adult spawning productivity.
	Altered longitudinal habitat connectivity	and rearing habitat availability Reduced availability of suitable habitats along longitudinal gradient.				<u>Juveniles</u> : Disconnection of floodplain habitats can lead to decreased availability and suitability of rearing habitat, and changes in food web complexity. Moderate gradient stream systems preferred by sculpins may limit the extent of suitable habitat area. Disconnection of sloughs and similar slow-flowing floodplain habitats in lower gradient systems may limit habitat area preferred by dace and juvenile suckers. These stressors may thereby result in decreased foraging opportunities and increased competition for suitable habitats, affecting survival, growth, and fitness. <u>Adults</u> : Disconnection of sloughs and			
							similar slow-water rearing habitats may limit the availability of suitable foraging and spawning habitat for dace. In moderate gradient habitats, disconnection of floodplain habitats may limit the availability and suitability of spawning habitat for mountain sucker, and foraging and spawning habitat for margined sculpins. These stressors may thereby result in decreased foraging opportunities, and increased competition for suitable habitats, affecting survival, growth, fitness, and by extension, spawning productivity.		

Sub- activity			Ex	posure				
Туре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Eggs (dace); Juveniles (dace and mountain suckers); Adults (dace and mountain suckers)	Eggs: Adult dace spawning habitat availability may be limited by latteral disconnection, and by limitations on movement in the nearshore zone.Increased egg density may in turn increase potential egg losses from predation, localized water quality impacts, or other mechanisms, limiting egg survival and/or incubation success. <u>Juveniles and adults</u> : LWD removal can fragment nearshore habitats, forcing juvenile fish moving along the shoreline to migrate into deeper water. Dace, which prefer shallow water habitats, would experience increased predation exposure and increased stress and exertion as a result. Concentration in nearshore habitats due to restricted movement may limit foraging opportunities. Exposure to these stressors may limit survival, growth, and fitness. Reduced adult fitness may affect spawning productivity. Juvenile and adult suckers will experience similar stressor exposure but are less prone to the resulting effects due to their benthic orientation.Margined sculpins are found predominantly in small rivers and streams in the Tucannon and Walla Walla River drainages. The likelihood of occurrence in lakes is limited, which in turn limits	
							the potential for stressor exposure in lacustrine environments.	
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Enco perm habit
	Aquatic Vegetation Modification							
	Riverine and Lacustrine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Cons</u> distu durin

Minimization Measures	Resulting Effects of the Submechanism
equire structures with the inimal footprint necessary to hieve project objectives. Avoid rmitting projects in areas where gnificant cumulative effects are ready prevalent.	May affect juvenile and adult survival, growth, and fitness. May affect egg survival and/or incubation success.
courage project designs that limit rmanent alteration of high-quality bitat features.	May affect juvenile survival.
<u>onstruction</u> : Avoid/minimize sturbance of aquatic vegetation ring project construction.	May affect juvenile growth and fitness.

Sub-			Exp	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

ıb-			Ex	posure		-		
tivity /pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Riparian Vegetation Modification	•	-	-	-		-	
	Riverine							
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs; Juveniles; Adults	Eggs: High water temperatures may decrease egg survival. <u>Juveniles</u> : Reduced growth and fitness caused by temperatures outside optimal growth range, and alteration of food web patterns. <u>Adults and juveniles</u> : May reduce the availability of suitable refuge and foraging habitat, leading to reduced survival, growth, and fitness. <u>Adults</u> : Spawning is temperature dependent; alteration of nearshore temperature may affect spawning success and productivity.	Avo ripa syste widt poss
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs:Decreased incubation success due to turbidity effects as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due	Avo ripar syste widt poss
							to decreased availability of suitable spawning habitat. Habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased availability of suitable foraging and refuge habitat, leading to decreased foraging opportunities, increased competition, increased predation exposure, collectively affecting survival, growth, and fitness. Reduction in suitable spawning habitat area may affect spawning productivity.	Enc limi qual

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of barian vegetation. Maintain stem-appropriate riparian buffer dths to the greatest extent sssible.	May affect survival, growth, and fitness at all life-history stages. Mountain sucker prefer deeper water environments and are likely to be less sensitive to these effects.
void/minimize disturbance of parian vegetation. Maintain stem-appropriate riparian buffer dths to the greatest extent ssible.	May affect survival, growth, and fitness at all life-history stages
acourage project designs that nit permanent alteration of high- ality habitat features.	May affect juvenile and adult survival, growth, and fitness. May affect adult spawning productivity.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margine

			Ex	posure					
t y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	All exposed life-history stages: Dace and sucker dependency on groundwater is currently a data gap. However, decreased availability of thermal refuge may affect survival during temperature extremes.	Avoid disturbance of vegetation along stream.	Effects resulting from this impact mechanism are uncertain, as dace and sucker sensitivity to stressor exposure is currently a data gap. However, lack of suitable thermal refuge habitat may affect dace survival.
	Lacustrine								•
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures).	Immer temperatures, (pronounced in permanent feet riparian vegetation. Maintain		May affect survival, growth, and fitness at all life-history stages. Mountain sucker prefer deeper water environments and are likely to be less sensitive to these effects.				
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs (dace); Juveniles; Adults	Eggs: Dace may experience decreased egg survival in lacustrine spawning environments due to turbidity effects. Juveniles and adults: Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect dace egg survival. See effects for related stressors under Water Quality Modification.
-	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Dace and suckers prey upon terrestrial insects recruited from riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth, fitness, and productivity.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Alteration of habitat complexity may affect the suitability of spawning, rearing, and refuge habitat for dace and suckers, leading to reduced survival, growth, and fitness. Reduced habitat complexity may affect the availability of suitable spawning habitats for dace and sucker.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect survival, growth, and fitness during juvenile and adult life- history stages. Reduced habitat complexity may affect spawning productivity.
-	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Dependence on groundwater– surface water exchange by these fish species is a data gap. However, lack of suitable thermal refuge habitat may lead to decreased survival during temperature extremes.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects resulting from this impact mechanism are uncertain, as dace and sucker sensitivity to stressor exposure is currently a data gap. However, lack of suitable thermal refuge habitat may affect dace survival.

ned	Sculpin,	and	Mountain	Sucker.
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Sub-			Ex	posure									
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism				
	Water Quality Modification												
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.				
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.				
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.				



Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawr	ning Substrate Aug	mentation							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specifi noise intensity and receptor exposur Should exposure occur, direct mortality or injury is probable.



			Ex	posure	1	,			
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae:Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification.Juveniles:Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.Adults:Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality and injury May affect survival, growth, and fitness at juvenile and adult life-histor stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. <u>Juveniles and adults</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.

			Ex	posure	1	·			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning succe and overall population productivity
	Altered bank stability (intermediate-term effects from passive augmentation projects) Altered substrate composition/stability	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term Short-term to long-term	Continuous	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. Dace are associated with low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations, egg burial, etc.) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, an fitness at egg and juvenile life- history stages. May affect spawning productivity.
-	Aquatic Vegetation Modification								
╞	Riverine				Γ				
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, grow and fitness.

· ACTIVITY			Ez	posure	T		4	
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.	
	Water Quality Modification							
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensu mini to ch short back pract proto turbi
In-Ch	annel/Off-Channel Construction and Maintenance Activities	Habitat Creation/Modific	cation					
	Riverine							
		Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate work

Minimization Measures	Resulting Effects of the Submechanism
asure project design avoids and/or inimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and rbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
efuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of juveniles and adults.
void construction activities during riods when individuals may be esent, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.

Sub-			Ex	posure	_	_			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality and injury. May affect survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	<u>Eggs and juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. <u>Juveniles and adults</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect juvenile and adult growth and fitness.

HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker. Table A-12 (continued).

Sub-			Ex	posure		ì					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Water Quality Modification										
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.		
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.		
Ripari	an Planting/Restor	ation Enhancement									
	Construction and Maintenance Activities										
	Riverine, Lacustrine	1									
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u> : Alteration of water temperatures leading to increases or decreases beyond optimal ranges may affect growth and fitness of dace and sucker. Optimal temperatures range from 59–64°F for dace and 55–70°F for mountain sucker. Exposure to higher temperatures may lead to direct mortality or sufficient stress to affect survival. Juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.		
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.		

Riverine, Lacustrine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs; Juveniles; Adults	All exposed life-history stages: Alteration of water temperatures leading to increases or decreases beyond optimal ranges may affect growth and fitness of dace and sucker. Optimal temperatures range from 59–64°F for dace and 55–70°F for mountain sucker. Exposure to higher temperatures may lead to direct mortality or sufficient stress to affect survival. Juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Min spe assi spe
	Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high	Min spec eros afte

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Spawning gravel sedimentation – due to removal of invasive riparian species					turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	
	Aquatic Vegetation Modification							
	Riverine, Lacustrine							
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Desig cano conti

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Minimization Measures	Resulting Effects of the Submechanism
sign riparian patches with variable hopy coverage so that sunlight will ntinue to reach the channel.	May affect survival, growth, and productivity of juvenile and adult life- history stages.

	Mechanism of Impact	Exposure							
tivity /pe		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification		-	-	-	-			
Riverine, Lacustrine									
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect survival, growth, and productivity of juvenile and adult life-history stages.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures).	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs; Juveniles; Adults	All exposed life-history stages: Alteration of water temperatures leading to increases or decreases beyond optimal ranges may affect growth and fitness of dace and sucker. Optimal temperatures range from 59–64°F for dace and 55–70°F for mountain sucker. Exposure to higher temperatures may lead to direct mortality or sufficient stress to affect survival. Juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival of incubating egg May affect juvenile and adult surviva growth, and fitness.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg May affect juvenile and adult surviv growth, and fitness.

			Ex	posure			_		
Mechanism o	of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
nd Creatior	n Restor	ration/Enhancement							
Construction and Maintenance A									
Riverine									
Equipment Oper	ration	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-histo stages, depending on project-speci noise intensity and receptor expose Should exposure occur, direct mortality or injury is probable.
Bank, Channel, Disturbance	Shoreline	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May aff juvenile and adult survival, growt and fitness. See effects of related stressor exposure under Water Qu Modification.

Sub-			Ех	posure			-		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality and injury. May affect survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect juvenile and adult growth and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.

Sub-			Ex	posure			_		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach	Nourishment/Cont	touring							
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. <u>Juveniles and adults</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.

			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification							-	-
1	Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Eggs (dace); Juveniles; Adults	<u>All exposed life-history stages</u> : Alteration in sediment supply can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juveniles and adults. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness, or mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all exposed life-history stages. Decreased fitness may lear reduced spawning productivity.
ľ	Aquatic Vegetation Modification								
	Lacustrine		1			1			[
1	Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.		May affect survival, growth, and productivity of juvenile and adult history stages.
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensu mini to ch short back pract proto turbi
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate work

Reef Creation/Restoration/Enhancement

Construction and Maintenance Activities								
Lacustrine								_
Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid construction activities during periods when individuals may be present, particularly juveniles.	
Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	

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Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
efuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the channel.	May affect survival, growth, and fitness of juveniles and adults.
void construction activities during riods when individuals may be esent, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
void/minimize cavitation to limit	May affect survival, growth, and

fitness due to avoidance behavior,

decreased foraging success, and

increased predation risk.

			Ex	posure	1	1			
V	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Qual Modification.
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind- driven waves are most pronounced)	Permanent	Continuous	Eggs (dace); Juveniles; Adults	All exposed life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift	May affect survival, growth, and fitness at all exposed life-history stages. Decreased fitness may le to reduced spawning productivity
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous		fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juveniles and adults. This may occur through a number of specific stressors, including	patterns, and wave energy and current patterns.	
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep		
	Altered sediment supply		Year-round	Permanent	Continuous	_	water habitat, food web alterations and decreased foraging opportunity, and		
	Altered substrate composition		Year-round	Permanent	Continuous		increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness, or mortality.		
	Ecosystem Fragmentation								
ļ	Lacustrine		I						I
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification	·					·		
[Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent	Continuous	Juveniles;	<u>Juveniles and adults</u> : Reduced foraging opportunities due to decreased food web	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning

Sub-			Ех	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered cover and habitat			(dependent on nature of activity)		Adults	productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Avoi produ
	Water Quality Modification							
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensur minir to chr short- backg practi proto turbic
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contro water work
Eel Gr Creati	ass and Other Aqu on/Restoration/Enl	natic Vegetation hancement						
	Not applicable							

Minimization Measures yoid nourishing beaches updrift of oductive, vegetated aquatic habitat.	Resulting Effects of the Submechanism productivity.
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
fuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the channel.	May affect survival, growth, and fitness of juveniles and adults.

			Ехр	osure					Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
er	Dam Removal/M	odification							
	Construction and Maintenance Activities								
	Riverine						-	-	-
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of all life stages.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Little is known about the effects of anthropogenic sounds on lamprey
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments).Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation.Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure.Adults: Delayed migration resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May affect survival, growth, and fitness at ammocoete, transformin adult, and adult life-history stage
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness of Transforming adults.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history-stages</u> : See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors un Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and ammocoetes; Transforming adults;	Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival, growth, and fitness at egg and ammocoete sta and egg and transforming adult li history stages for host fish of Pac

Sub-			Exp	osure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	N
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal	Adults	success and ammocoete survival. Pacific and river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for	designs channel substrat groundv extent p
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal		several years. <u>Transforming adults</u> : Altered channel	
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous		geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for	
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation)	Intermediate-term to long-term	Continuous		suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of s) if potential spawning habitat is affected	
	Ecosystem							
	Fragmentation Riverine							
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen Decreased dissolved oxygen from	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most	Permanent	Seasonal	Eggs and ammocoetes	Eggs and ammocoetes: See related stressor responses under Water Quality Modification	Avoid d through
		eutrophication below the impoundment (caused by elevated nutrient export)	extensive)					
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid d through
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults;	<u>All exposed life-history stages</u> : This stressor may limit the availability of adult spawning and transforming adult rearing habitat for lamprey species dependent on these habitat	Require effects of permitti that lead
		Reduced foraging opportunities and rearing habitat availability				Adults	types.	quality 1
	Aquatic Vegetation codification							
	Riverine		1		1	1		
	Altered autochthonous production	Reduced food web productivity, reduced foraging opportunity,	Year-round	Permanent	Continuous	Ammocoetes; Transforming	<u>Ammocoetes and transforming adults</u> : Reduced foraging opportunities due to	Avoid d through

Minimization Measures gns that minimize effects on nel geometry, flow velocity, trate composition, and ndwater exchange to the greatest nt practicable.	Resulting Effects of the Submechanism and river lamprey. May also affect spawning productivity.

void draining impounded area rough use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
void draining impounded area rough use of beaver deceivers.	May affect survival, growth, and fitness of all life history stages
equire assessment of the hydraulic fects of the project before ermitting; avoid permitting designs tat lead to disconnection of high uality floodplain habitat.	May affect survival at egg, ammocete, and transforming adult life-history stages. May affect spawning productivity.
void draining impounded area rough use of beaver deceivers.	May affect ammocoete and transforming adult growth and fitness.

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tivity /pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered cover and habitat	reduction in available cover				adults	decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	
	Riparian Vegetation Modification							
	Riverine							
	Altered stream bank and shoreline stability	Increased suspended solids Burial of benthic ammocoetes or eggs.	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	Eggs/ammocoetes: Decreased incubation success due to burial or scour of eggs and rearing ammocoetes. Decreased availability of host fish for Pacific and river lamprey. <u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults</u> : Potential effects on migration and spawning productivity as described for related stressor responses under Water Quality Modification.	Initia meas const impo disco sedin
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Ammocoetes; Transforming adults	<u>Transforming adults and ammocoetes:</u> Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Repla native invas
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Repla nativ invas
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Transforming adults; Adults	<u>Transforming adults and adults</u> : See related stressor responses under Water Quality Alteration. Effects are related to host fish effects for both Pacific and river lamprey.	Repla nativ invas

Minimization Measures	Resulting Effects of the Submechanism
nitiate proper erosion control neasures both during and after onstruction. Replant former npoundment with native vegetation to iscourage invasives and stabilize ediments.	May affect survival, growth, and fitness during incubation and transforming adult and adult fitness of host fish for Pacific and river lamprey.
eplant former impoundment with ative vegetation to discourage avasives and stabilize sediments.	May affect growth and fitness of ammocoetes and transforming adults.
eplant former impoundment with ative vegetation to discourage avasives and stabilize sediments.	May affect survival, growth, and fitness of all life history stages
eplant former impoundment with ative vegetation to discourage avasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.

Sub-	-		Exp	osure	1	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. <u>Transforming adults and adults</u> : Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of all exposed life-history stages.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects on host fish are stressors to Pacific and river lamprey. <u>Transforming adults and adults</u> : A physiological response to exposure at toxic levels causing mortality or injury leading to reduced fitness is a data gap. However, effects on host fish are known and would affect Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. This is a data gap.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult survival, growth, and fitness, as well as adult survival, productivity, and spawning success.
Placem	Woody Debris nent/Movement/Re onstruction impact Construction and Maintenance Activities	emoval (for placement s apply)							
	Riverine, Lacustrine, Marine								

Working Draft–Do Not Cite Habitat Modification

			Exp	osure					
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life stages.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Transforming adults, Adults	Adults and transforming adults: Very little is known of the effects of anthropogenic sounds on lamprey at any life-history stage.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Little is known about the effects of anthropogenic sounds on lamprey
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors un Water Quality Modification.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes:Mortality, injury, and stress, during dewatering (when buried in riverine sediments).Adults and transforming adults:Mortality, injury, or stress from capture, handling, and relocation.Transforming adults:Increased competition once relocated, and reduced growth and fitness; increased predation exposure.Adults:Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transformir adult, and adult life-history stages

Sub-	_		Exp	osure	1	1					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor				
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	<u>Transforming adults</u> : Injury or mortality from entrainment or impingement.	Insta cons Adh worl trans			
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Ammocoetes: Ammocoetes: Ammocoetes of Pacific and river lamprey mature buried in fine substrates in the lower reaches and estuaries of larger rivers for extended periods and are therefore vulnerable to direct injury and mortality from benthic disturbance.Transforming adults: Decreased foraging opportunity due to short-term reduction in prey availability.All life-history stages: Quality Modification.	Adh worl egg			
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limi grea			
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Mortality or injury from entrainment. Transforming adults: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avo back			
	Hydraulic and Geomorphic Modification										
	Riverine										
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and ammocoete survival. Pacific and river lamprey ammocoetes are particularly	Care desig impa proje desig chan			
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for several years.	subs grou exter			
	Altered substrate composition]	Year round	Permanent	Continuous]	Transforming adults: Altered channel geometry, flow velocity, and substrate				

Minimization Measures	Resulting Effects of the Submechanism
nstall and maintain pump screens onsistent with WDFW protocols. Indhere to system-specific in-water york windows, avoid use when ransforming adults are present.	May affect survival and fitness at transforming adult life-history stage.
Adhere to system-specific in-water ork windows. Avoid work during gg incubation periods.	May cause direct mortality or injury to ammocoetes. May affect transforming adult growth and fitness. See effects for related stressors under Water Quality Modification.
imit area of dewatering to the reatest extent practicable.	May affect growth and fitness of Transforming adults.
avoid turbidity effects above ackground levels.	May affect Transforming adults growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
Carefully evaluate project siting and esign and consider the magnitude of mpact mechanisms produced by the roject. Encourage selection of project esigns that minimize effects on hannel geometry, flow velocity, ubstrate composition, and roundwater exchange to the greatest xtent practicable.	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life- history stages for host fish of Pacific and river lamprey. May also affect spawning productivity.

Sub-			Exp	osure	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
1 ype	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation)	Permanent	Continuous		composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of s) if potential spawning habitat is affected	
	Marine						of s) it potential spawning natinal is affected	
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer)	Permanent	Continuous	Transforming adults; Adults (river lamprey)	<u>Transforming adults and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore	Care: desig impa proje desig
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for lamprey host fish, leading to decreased foraging opportunities for transforming adult Pacific and river lamprey, and adult river lamprey.	sedin patte patte
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous			
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous			
	Lacustrine		_	1				
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Rearing lamprey ammocoetes are found buried in nearshore lacustrine sediments. Modification of hydraulic and geomorphic conditions may alter habitat suitability, leading to limitations on the amount of available habitat and affecting	Care desig impa proje proje on se

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and current tterns.	May affect growth and fitness at transforming adult life-history stages through effects on host fish. River lamprey are also known to use nearshore habitats during the adult life-history stage and will be subject to these effects during this period. Direct dependence on nearshore habitat characteristics for both species is a data gap. Decreased growth and fitness may affect survival and productivity during ocean migration life-history phase for both species. Western brook lamprey are non- anadromous and will not be exposed to these stressors.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the ject. Encourage selections of oject designs that minimize effects sediment supply, longshore drift	May affect survival, growth, and fitness at ammocoete life-history stage. Effects on host fish may decrease survival, growth, and fitness of transforming adult and adult lamprey, and spawning productivity of adult

Sub-			1					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		survival, growth, and fitness at this life- history stage. <u>Transforming adults and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater	patt patt
	Altered sediment supply	-	Year-round	Permanent	Continuous	-	inputs are core ecosystem processes and	
	Altered substrate composition		Year-round	Permanent	Continuous		characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host fish, leading to decreased foraging opportunities for adults and transforming adults. Decreased foraging opportunities may cause decreased growth and fitness, affecting survival during marine migration and spawning productivity.	
	Ecosystem Fragmentation							
	Riverine							
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and ammocoetes	Eggs and ammocoetes: See related stressor responses under Water Quality Modification	Requestion
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	
	Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: : LWD removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and larval rearing habitat for lamprey species. LWD removal may also affect the transport of lamprey ammocoetes to suitable rearing habitats, potentially affecting ammocoete survival. Decreased habitat availability may lead to density-dependent effects on adult spawning success. Adult brook lamprey may also be affected by decreased availability of suitable foraging habitat.	Req effec perm that habi simp
	Marine	1 						
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Transforming adults Adults	Transforming adults and adults: LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging XXX to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avo proje cum prev

Minimization Measures terns, and wave energy and current terns.	Resulting Effects of the Submechanism lamprey.
quire assessment of the hydraulic ects of the project before permitting.	See effects for related stressors under Water Quality Modification.
	May affect survival, growth, and fitness of all life history stages
quire assessment of the hydraulic ects of the project before mitting; avoid permitting designs it lead to disconnection of floodplain oitat or longitudinal reach aplification.	May affect survival at egg, ammocete, and transforming adult life-history stages. May affect spawning productivity.
oid permitting LWD removal ojects in areas where significant mulative effects are already evalent.	May affect survival and productivity at XXX life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.

ıb-			Expo	sure	<u></u>	1					
tivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor				
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Transforming adults; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Enc perr habi			
	Lacustrine										
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Adults	<u>All exposed life-history stages</u> : LWD removal in lacustrine environments can fragment nearshore rearing and spawning habitat, forcing migrating and foraging XXX to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Req foot obje in a effe			
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Transforming adults; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Enco perm habit			
	Aquatic Vegetation Modification										
	Marine										
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Transforming adults; Adults	Transforming adults and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	<u>Cons</u> distu durin			
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Transforming adults; Adults	<u>Transforming adults and adults</u> : See related stressor responses under Water Quality Modification.				
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	<u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness of Pacific and river lamprey host fish.				
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity, with resulting decreased growth and reproductive fitness of Pacific and river lamprey. River lamprey use nearshore habitats during this				

Minimization Measures	Resulting Effects of the Submechanism
courage project designs that limit rmanent alteration of high-quality bitat features.	May affect transforming adult and adult survival.
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival at XXX life- history stage. Decreased fitness may lead to reduced spawning productivity.
courage project designs that limit rmanent alteration of high-quality bitat features.	May affect transforming adult and adult survival.
onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	May affect river lamprey transforming adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.
	See effects for related stressors under Water Quality Modification.
	May affect transforming adult survival and productivity. May affect adult growth and spawning productivity of Pacific and river lamprey host fish. Other effects on adult river lamprey are a data gap.

Sub-								
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Ammocoetes; Transforming adults	<u>Ammocoetes and transforming adults</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous production for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	<u>Cons</u> distu durin
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Transforming adults; Adults	Transforming adults and adults: See related stressor responses under Water Quality Alteration. Effects are related to host fish effects for both Pacific and river lamprey.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u> : Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life- history stages are a data gap. Although effects of altered autochthonous inputs on Western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	
	Riparian Vegetation Modification							
	Riverine							
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: exposed to temperatures over 68°F for continuous periods.Transforming adults: Altered growth and fitness when exposed to temperatures outside optimal growth range, and alteration of food web patterns, including food web supporting Pacific and river lamprey host fish.Adults and transforming adults: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoi ripar appr the g

Minimization Measures	Resulting Effects of the Submechanism
onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	May affect ammocoete and transforming adult growth and fitness.
	See effects for related stressors under Water Quality Modification.
	Lamprey dependence on habitat complexity provided by freshwater aquatic vegetation is a data gap.
yoid/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible	May affect survival, growth, and fitness during incubation, rearing, and spawning.

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	Eggs/ammocoetes: Decreased incubation success due to burial or scour of eggs and rearing ammocoetes. Decreased availability of host fish for Pacific and river lamprey. <u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults</u> : Potential effects on migration and spawning productivity as described for related	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation and transforming adult and adult fitness of host fish for Pacific and river lamprey.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity,	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	stressor responses under Water Quality Modification. <u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of host fish for Pacific and river lamprey.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect growth and fitness of transforming adults. May affect adult spawning success.
		reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)					<u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat for host fish of Pacific and river lamprey. Decreased suitable lamprey spawning habitat.		
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and ammocoetes; Adults	Lamprey responses to groundwater exchange are a data gap.	Avoid disturbance of vegetation along stream.	Lamprey dependence on groundwater exchange is currently a data gap. Therefore, the effects of stressor exposure are unknown.
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Transforming adults; Adults	<u>Transforming adults</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, transforming adult Pacific and river lamprey trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress. Similar effects on Pacific and river lamprey host fish may affect foraging success. <u>Adults</u> : River lamprey adults are found in nearshore environments and may experience	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of transforming adult Pacific and river lamprey, as well as adult river lamprey.
							similar effects as described above. Similar effects on river lamprey host fish may affect foraging success, leading to decreased growth and spawning fitness.		

Ē			Exp	osure		1			
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Transforming adults; Adults	Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> River lamprey adults are found in nearshore environments and may experience similar effects as described above. Similar effects on river lamprey host fish may affect foraging success, leading to decreased growth and spawning fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of transforming adult Pacific and river lamprey, as well as adult river lamprey.
-	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Transforming adults; Adults	Transforming adults:Pacific and riverlamprey host fish depend on allochthonousinputs from marine riparian vegetation.Effects on host fish survival growth andfitness may in turn affect lamprey growth andfitness. Those host fish that feed on benthicorganisms (such as mollusks and amphipods)are likely linked to allochthonous materialinputs.Adults:Adults:Adult river lamprey experience sameeffects as above.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	For Pacific and river lamprey, effec would be related only to host fish dependence on allochthonous inputs Western brook lamprey have no marine life-history stage.
-	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	<u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of host fish for Pacific and river lamprey. <u>Adults</u> : Adult river lamprey experience same effects as above.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect transforming adult survival, growth, and fitness; adult spawning success; and overall population productivity.
-	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Transforming adults; Adults	<u>Transforming adults and adults (river</u> <u>lamprey</u>): Lamprey dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from the impact mechanism are unknown.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Altered water temperatures due to riparian modification could limit habitat	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete survival, growth, and fitness. May affect growth and fitness of adults and transforming adults.

	Exposure							Deculting Effects of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		extremes)				suitability, affecting survival, growth, and fitness. <u>Adults and transforming adults</u> : Adult lamprey dependence on nearshore lacustrine habitats is currently a data gap. However, transforming adult host fish of Pacific and river lamprey may become trapped in isolated habitats, which may increase temperatures and potentially lead to mortality or increased thermal stress and decreased fitness of host fish, affecting foraging opportunities for adults and transforming adults.		
Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Alteration of shoreline stability could lead to increased sedimentation and burial, affecting larval survival.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete survival. affect growth and fitness of adults transforming adults.
					0	<u>Adults and transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Lamprey dependence on allochthonous inputs from shoreline riparian vegetation is a data gap. However, Pacific and river lamprey ammocoete benthic filter feeding stage and the filter feeding of the western brook lamprey could be affected. This could be a stressor to the extent the host fish is stressed by this mechanism of impact.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete, transform adult, and adult growth and fitnes depending on species.
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Intermediate-term to permanent (dependent on nature of activity and time required for recovery)	Continuous	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Decrease in availability of suitable rearing habitat, leading to decreased survival, growth, and fitness. <u>Transforming adults and adults</u> : Decreased refuge habitat availability and foraging opportunities for host fish, potentially leading to decreased foraging opportunities for Pacific and river lamprey with resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect ammocoete survival, growth, and fitness. May affect ac growth, fitness, and spawning productivity due to effects on host
Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Lamprey dependence on groundwater inflow in lacustrine habitats is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects of the action resulting fror impact mechanism are unknown.

Sub-			Exp	osure	1			
ictivity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Spawn	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. <u>Transforming adults and adults</u> : Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensur and/o leadir Avoid above exten establ sedir
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensur drasti comp
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects on host fish are stressors to Pacific and river lamprey. <u>Transforming adults and adults</u> : A physiological response to exposure at toxic levels causing mortality or injury leading to reduced fitness is a data gap. However, effects on host fish are known and would affect Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. This is a data gap.	Ensur drasti comp

8	8						
Construction and Maintenance Activities							
Riverine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refue contr water work

Minimization Measures	Resulting Effects of the Submechanism
Ensure that project design avoids and/or minimizes habitat alterations eading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
Ensure project design does not Irastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of transforming adults and adults.
Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult survival, growth, and fitness, as well as adult survival, productivity, and spawning success.
Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life stages.

Sub-		Exposure						
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Limit practi winde life h Avoie banks
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history-stages</u> : See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoie ripari shore prope
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults;	Eggs and ammocoetes, transforming adults: Injury or mortality from burial during gravel placement.	Restr perio ammo least
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit distur pract
	Hydraulic and Geomorphic Modification							
	Riverine							
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Transforming adults; Adults	<u>Transforming Adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Ensu prope
							<u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and ammocoetes; Transforming adults;	Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and ammocoete survival. Pacific and	Caref desig impac proje desig

Minimization Measures	Resulting Effects of the Submechanism
mit in-water equipment use where acticable. Adhere to in-water work ndows to avoid effects on multiple e history stages where possible. void dumping gravel from high nks.	Little is known about the effects of anthropogenic sounds on lamprey.
void/minimize disturbance of aarian vegetation. Limit bank, oreline and benthic disturbance. Use oper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
estrict in-water work window to riods when incubating eggs and amocoetes with limited motility are ast likely to be present.	May cause direct mortality or injury at egg, ammocete, and transforming adult life-history stages. Injury and stress may affect survival, growth, and fitness.
mit area of dewatering and benthic sturbance to the greatest extent acticable.	May affect growth and fitness of Transforming adults.
sure that project has been designed operly for ecosystem context.	May affect transforming adult growth and survival, as well as reproductive success and overall population productivity.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life- history stages for host fish of Pacific and river lamprey. May also affect

Sub-Exposure activity Mechanism of Impact When Duration Life-history Form Туре Stressor Frequency **Response to Stressor** river lamprey ammocoetes are particularly cha Adults Altered substrate Short-term to longvulnerable to impact mechanisms that cause sub composition/stability term scour, deposition, or other forms of substrate gro modification when buried in fine substrates exte during rearing periods, which can last for several years. Transforming adults: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of s) if potential spawning habitat is affected Aquatic Vegetation Modification Riverine Reduced foraging opportunities Altered autochthonous Year-round Short-term to Continuous Ammocoetes; Ammocoetes and transforming adults: Av Reduced foraging opportunities due to production permanent pro Transforming decreased food web productivity, decreased (dependent on nature veg adults growth and fitness of Pacific and river of activity) hat lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability. Year-round Short-term to All exposed life-history stages: Reduced Altered habitat complexity Reduced food web productivity, Continuous Ammocoetes; foraging opportunities due to decreased food reduced foraging opportunity, permanent Transforming web productivity, decreased growth and reduction in available cover (dependent on nature adults; fitness of Pacific and river lamprey host fish, of activity) Adults and decreased prey resources for filter feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete lifehistory stages are a data gap. Although effects of altered autochthonous inputs on Western brook lamprey are a data gap, alterations could be expected to affect prey resource availability Water Quality

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Modification

Minimization Measures annel geometry, flow velocity, ostrate composition, and oundwater exchange to the greatest tent practicable.	Resulting Effects of the Submechanism spawning productivity.
oid spawning gravel augmentation ojects in locations where aquatic getation plays a strong role in bitat productivity.	May affect ammocoete and transforming adult growth and fitness.
	Lamprey dependence on habitat complexity provided by freshwater aquatic vegetation is a data gap.

Sub-			Exp	osure					
activity Type	Mechanism of Impact	Stressor When		Duration	Frequency	Life-history Form	Response to Stressor		
In-Ch	Altered suspended solids	Increased suspended solids Habitat Creation/Modifie	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. <u>Transforming adults and adults</u> : Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu minin to ch short backg pract proto turbid	
	Construction and Maintenance Activities								
	Riverine							_	
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refue contr water work	
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	Adults and transforming adults: Very little is known of the effects of anthropogenic sounds on lamprey at any life-history stage.	Avoi thres Fishe by sp work heav	
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history-stages</u> : See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoid ripari shore prope	

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
fuel and service machinery in a ntrolled environment away from the ter body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of all life stages.
void noise in excess of impact resholds established by NOAA sheries and USFWS in habitats used y species. Limit work to in-water ork windows Limit in-water use of eavy machinery.	Little is known about the effects of anthropogenic sounds on lamprey.
roid/minimize disturbance of arian vegetation. Limit bank, oreline and benthic disturbance. Use oper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

_		Exp	osure	1	I			Resulting Effects of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments).Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation.Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure.Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transforming adult, and adult life-history stages.
	Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	<u>Transforming adults</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when transforming adults are present.	May affect survival and fitness at transforming adult life-history stag
	Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	<u>Ammocoetes:</u> Ammocoetes of Pacific and river lamprey mature buried in fine substrates in the lower reaches and estuaries of larger rivers for extended periods and are therefore vulnerable to direct injury and mortality from benthic disturbance.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May cause direct mortality or injur ammocoetes. May affect transform adult growth and fitness. See effect for related stressors under Water Quality Modification.
						<u>Transforming adults</u> : Decreased foraging opportunity due to short-term reduction in prey availability.		
						<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.		
	Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering and benthic disturbance to the greatest extent practicable.	May affect growth and fitness of Transforming adults.
	Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Mortality or injury from entrainment. Transforming adults: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect Transforming adults growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub-			Exp	osure	I	1		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. <u>Transforming adults and adults</u> : Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensur and/oi leadin Avoid above extent establ sedim
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue contro water work

Riparian Planting/Restoration Enhancement

Riverine , Lacustrine, Marine						
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Ammocoetes; Transforming adults; Adults	Ammocoetes:Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Altered water temperatures due to riparian modification could limit habitat suitability, affecting survival, growth, and fitness.Adults and transforming adults:Adult lamprey dependence on nearshore lacustrine habitats is currently a data gap. However, transforming adult host fish of Pacific and river lamprey may become trapped in isolated habitats, which may increase temperatures and potentially lead to mortality or increased thermal stress and decreased fitness of host fish, affecting foraging opportunities for adults and transforming adults.

Resulting Effects of the Submechanism
May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
May affect survival, growth, and fitness of all exposed life-history stages.
May affect ammocoete survival, growth, and fitness. May affect growth and fitness of adults and transforming adults.

b-			Exp	osure					
tivity /pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Benthic sedimentation – due to	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults;	<u>All life-history-stages</u> : See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish,	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
		removal of invasive riparian species		(included)		Adults	effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.		
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history-stages</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the aqueous environment.	May affect river lamprey transformin adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine					9			
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history-stages</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the aqueous environment.	May affect river lamprey transformin adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Ammocoetes; Transforming adults; Adults	Ammocoetes: Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Altered water temperatures due to riparian modification could limit habitat suitability, affecting survival, growth, and fitness. <u>Adults and transforming adults</u> : Adult lamprey dependence on nearshore lacustrine habitats is currently a data gap. However, transforming adult host fish of Pacific and river lamprey may become trapped in isolated habitats, which may increase temperatures and potentially lead to mortality or increased thermal stress and decreased fitness of host fish, affecting foraging opportunities for adults and transforming adults.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect ammocoete survival, growth, and fitness. May affect growth and fitness of adults and transforming adults.

Sub-			Exp	oosure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. <u>Transforming adults and adults</u> : Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini to ch short back pract proto turbi
Wetla	Construction and	ration/Enhancement						
	Maintenance Activities Riverine and Marine							
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refu contr wate work
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Limi pract wind life f Avoi bank
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoi ripar shore prope

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
fuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of all life stages.
mit in-water equipment use where acticable. Adhere to in-water work ndows to avoid effects on multiple e history stages where possible. void dumping gravel from high nks.	Little is known about the effects of anthropogenic sounds on lamprey.
void/minimize disturbance of varian vegetation. Limit bank, preline and benthic disturbance. Use oper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

ub-								
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments).Adults and transforming adults: Injury, or stress from capture, handling, and relocation.Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure.Adults: Delayed migration resulting in decreased fitness and spawning success.	Use Fish avoi
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	<u>Transforming adults</u> : Injury or mortality from entrainment or impingement.	Insta cons Adhe work trans
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	<u>Ammocoetes:</u> Ammocoetes of Pacific and river lamprey mature buried in fine substrates in the lower reaches and estuaries of larger rivers for extended periods and are therefore vulnerable to direct injury and mortality from benthic disturbance. <u>Transforming adults</u> : Decreased foraging opportunity due to short-term reduction in prey availability.	Adh work egg
							<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Lim distu prac

Minimization Measures	Resulting Effects of the Submechanism
te protocols established by NOAA sheries and WDFW/WSDOT to oid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transforming adult, and adult life-history stages.
stall and maintain pump screens nsistent with WDFW protocols. lhere to system-specific in-water ork windows, avoid use when nsforming adults are present.	May affect survival and fitness at transforming adult life-history stage.
lhere to system-specific in-water ork windows. Avoid work during g incubation periods.	May cause direct mortality or injury to ammocoetes. May affect transforming adult growth and fitness. See effects for related stressors under Water Quality Modification.
mit area of dewatering and benthic sturbance to the greatest extent acticable.	May affect growth and fitness of Transforming adults.

Sub-			Exp	osure	Γ	ſ		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. <u>Transforming adults and adults</u> : Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu and/c leadii Avoi abov exten estab sedin
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensu: drasti comp

Beach Nourishment/Contouring

		Marine and Lacustrine									
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refu contr wate work				
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes:Littoral disturbance in lacustrine areas may lead to direct mortality and decreased survival of eggs and ammocoetes.Transforming adults:Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid produ comn				

Minimization Measures	Resulting Effects of the Submechanism
nsure that project design avoids nd/or minimizes habitat alterations eading to chronic bank instability. void short-term turbidity effects bove background levels to greatest attent practicable. Adhere to stablished protocols for managing ediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
nsure project design does not rastically reduce hydraulic omplexity or impact riparian buffers.	May affect survival, growth, and fitness of transforming adults and adults.
efuel and service machinery in a ontrolled environment away from the vater body. Limit heavy machinery vork within the project area.	May affect survival, growth, and fitness of all life stages.
void project site which are roductive and have a healthy benthic ommunity.	May affect survival of incubating eggs and ammocoetes. May affect growth and fitness at transforming adult life- history stage.

7			Exp	osure									
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism				
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Littoral disturbance in lacustrine areas may lead to direct mortality and decreased survival of eggs and ammocoetes. <u>Transforming adults</u> : Short-term reduction in foraging opportunity, increased competition,	Avoid project site which are productive and have a healthy benthic community.	May affect survival of incubating e and <u>ammocoetes</u> . May affect grow and fitness at <u>Transforming adult li</u> history stage.				
	Aquatic Vegetation						decreased growth and fitness.						
	Modification												
Ī	Marine and Lacustrine												
-	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults	<u>Ammocoetes and transforming adults:</u> Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect ammocoete and transforming adult growth and fitm				
	Altered cover and habitat	Reduced cover					lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous production for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.						
_	Water Quality Modification Marine and Lacustrine												
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. <u>Transforming adults and adults</u> : Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating of and ammocoetes. May affect transforming adult growth and fitm as well as adult fitness and spawni success.				
A	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of transforming adults and adults.				

			Exp	osure			4		Resulting Effects of the				
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism				
C	reation/Restoratio	n/Enhancement											
1	Construction and												
	Maintenance Activities												
	Marine and Lacustrine		1	1	1	1	1						
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible. Avoid dumping gravel from high banks.	Little is known about the effects anthropogenic sounds on lampre				
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Transforming adults; Adults	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	Little is known about the effects anthropogenic sounds on lamprey				
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history-stages</u> : See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors un Water Quality Modification.				
	Hydraulic and Geomorphic Modification												
	Marine												
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitabilityYear-round (with stressor exposure occurring in spring and summer)Perma	Permanent	Continuous	Transforming adults; Adults	<u>Transforming adults and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	Effects on host fish may decrease survival, growth, and fitness of transforming adult and adult lam and spawning productivity of adul lamprey.					
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host fish, leading to decreased foraging opportunities for adults and transforming adults. Decreased foraging opportunities may cause decreased	sediment supply, longshore drift patterns, and wave energy and current patterns.					
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		growth and fitness, affecting survival during marine migration and spawning productivity.						
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous								

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vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor							
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous									
	Lacustrine		1	1										
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u> : Rearing lamprey ammocoetes are found buried in nearshore lacustrine sediments. Modification of hydraulic and geomorphic conditions may alter habitat suitability, leading to limitations on the amount of available habitat and affecting survival, growth, and fitness at this life-	Care desi imp proj desi sedi patte						
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous		history stage. <u>Transforming adults and adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and	patt						
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host fish,							
	Altered sediment supply	_	Year-round	Permanent	Continuous		leading to decreased foraging opportunities							
	Altered substrate composition		Year-round	Permanent	Continuous		for adults and transforming adults. Decreased foraging opportunities may cause decreased growth and fitness, affecting survival during marine migration and spawning productivity.							
	Ecosystem Fragmentation													
	Marine													
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Transforming adults	<u>Transforming adults</u> : Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Ave prop mig incr						
	Lacustrine		-											
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Transforming adults	<u>Transforming adults</u> : Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Ave proz mig incr						
	Aquatic Vegetation Modification													
	Marine													

r	
arefully evaluate project siting and esign and consider the magnitude of npact mechanisms produced by the roject. Encourage selection of project esigns that minimize effects on ediment supply, longshore drift atterns, and wave energy and current atterns.	May affect survival, growth, and fitness at ammocoete life-history stage. Effects on host fish may decrease survival, growth, and fitness of transforming adult and adult lamprey, and spawning productivity of adult lamprey.
void placement of reef projects in roximity to Transforming adults sigratory corridors, such that acreased predation exposure may ccur.	May affect Transforming adults survival, growth and fitness.
void placement of reef projects in roximity to Transforming adults higratory corridors, such that creased predation exposure may ccur.	May affect Transforming adults survival, growth and fitness.

Sub-Exposure activity **Mechanism of Impact** When Duration Life-history Form **Response to Stressor** Туре Stressor Frequency Altered cover and habitat Increased predation risk Year-round Short-term to Continuous Transforming Transforming adults: Decreased refuge Av adults; habitat availability and foraging opportunities, permanent ves (dependent on nature leading to increased competition and Adults predation exposure, resulting in decreased of activity) survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity. Lacustrine Reduced foraging opportunities Transforming adults and adults: Reduced Altered autochthonous Year-round Short-term to Continuous Transforming Av adults; foraging opportunities due to decreased food production permanent veg web productivity; decreased growth and (dependent on nature Adults Altered cover and habitat fitness of Pacific and river lamprey host fish. of activity) Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities. Water Quality Modification Altered suspended solids Dependent on Temporary to short-Intermittent to Eggs and ammocoetes: Turbidity sufficient to Eggs and Car Increased suspended solids contributing term (dependent on interannual-decadal ammocoetes; cause fine sediment embeddedness or des (dependent on mechanism of impact contributing increased burial depth may lead to direct Transforming im mortality and decreased survival of eggs and contributing mechanism of adults; pro mechanism of ammocoetes. impact) des Adults impact) Transforming adults and adults: Not a direct sed stressor to the lamprey. For Pacific and river pat lamprey, responses depend on stressor pat magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success. Altered pollutant loading Transforming All affected life-history stages: Physiological Leaching of toxic substances Continuous with Use Year-round Intermediate-term adults; (depending on composition of reef responses to exposure at toxic levels, causing seasonal pulses material) mortality or injury leading to reduced fitness. (dependent on Adults current velocity) Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement

Construction and Maintenance Activities Marine

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of aquatic egetation during project construction.	May affect Transforming adult survival. May affect adult growth and reproductive productivity.
void/minimize disturbance of aquatic egetation during project construction.	May affect river lamprey transforming adult and adult growth and fitness, as well as productivity of Pacific and
	river lamprey host fish.
arefully evaluate project siting and esign and consider the magnitude of npact mechanisms produced by the roject. Encourage selection of project esigns that minimize effects on ediment supply, longshore drift atterns, and wave energy and current atterns.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
se non-toxic reef material.	May affect survival, growth, and fitness of transforming adults and adults.

Sub-		Exposure								
activity Type	Mechanism of Impact	Stressor When		Duration	Duration Frequency		Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Transforming adults; Adults	<u>Transforming adults and adults</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Adhere to system-specific in-water work windows.	Little is known about the effects of anthropogenic sounds on lamprey.	
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Transforming adults; Adults	<u>Transforming adults and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.	

Table A-14. HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

			-					T
y			Ex	posure			-	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Dam Removal							
2	on do not inhabit a	reas where beaver are ac	tive, thus beaver	dam removal w	vill not significa	ntly affect Stu	irgeon	
	Woody Debris	maral (for placement						
	nstruction impacts	moval (for placement s apply)						
	Construction and							
	Maintenance Activities							
	Riverine, Lacustrine, Marine							
	Equipment Operation	Elevated Hydrocarbons (associated	During project construction activities	Temporary to short-	Interannual to decadal	Eggs;	All life-history stages: See responses described for related stressors under Water	Ref
		with potential fuel and oil spills)	construction activities	term	decadai	Larvae; Juveniles;	Quality Modification.	con wat
						Adults		WO
		Elevated noise, visual, physical	During project	Temporary (auditory	Interannual to	Juveniles;	Juveniles: Auditory masking may affect	Alt
		disturbance	construction and maintenance activities	masking) to short- term (hearing	decadal (during project construction	Adults	ability to avoid predators, leading to effects on survival. Behavioral responses	eff stu
				threshold effects)	and maintenance)		may lead to habitat avoidance, affecting growth and fitness.	mi wa
						<u>Adults</u> : May cause avoidance behavior.	wa	
							Note: While these responses are	
							possible, very little is known of the effects of anthropogenic sounds on	
							sturgeon at any life-history stage, so the actual effects of stressor exposure are	
							uncertain.	
	Bank, Channel, Shoreline	Increased suspended solids	Year-round (with	Intermediate-term to	Continuous to	Eggs and larvae;	All life-history stages: See responses to	Av
	Disturbance		specific stressors prominent during high	long-term (dependent on time required for	seasonal (dependent on specific stressor)	Juveniles; Adults	related stressors under Water Quality Modification.	ripa sho
			flow conditions)	riparian recovery)		Adults		pro
								1
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ł			I					I

Minimization Measures

Resulting Effects of the Submechanism

efuel and service machinery in a ontrolled environment away from the vater body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of all life history stages.
Ithough, little is known about the ffects of anthropogenic sounds on urgeon, it is prudent to avoid/ inimize noise intensity during in- rater work.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.
void/minimize disturbance of parian vegetation. Limit bank, noreline and benthic disturbance. Use roper erosion control BMPs.	See effects for related stressors under Water Quality Modification

		Exposure							
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Juveniles and larvae</u> : Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury larvae and juveniles. Stress from relocation may affect survival, grow and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. <u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : May cause avoidance behavior, potentially delaying migration.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg a larval life-history stages. May affect juvenile survival, growth, and productivity. May cause adu avoidance behavior, potentially delaying migration and limiting spawning productivity; however, actual sensitivity to these stresso is a data gap.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Non-mobile eggs and larvae may experience injury or mortality from dredge entrainment. Juveniles and adults: Decreased growth and fitness due to stress and exertion caused by avoidance behavior and decreased foraging opportunity caused by short-term reduction in prey availability. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May cause direct injury or mortality of eggs and larvae. Ma affect juvenile growth and fitnes See effects for related stressors under Water Quality Modification
	Hydraulic and Geomorphic Modification								
	Riverine							1	
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles Adults	Eggs and larvae: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation. Changes in channel morphology, flow velocity, and substrate	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at egg and larva life-history stages. May affect juver growth and fitness. May affect adul spawning productivity.

Sub-								
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal		composition can alter substrate composition and stability, leading to decreased incubation success, and potentially increased predation exposure. Changes in flow regime may cause larvae	chan subs grou exter
	Altered substrate composition		Year round	Permanent	Continuous		to be transported to environments unfavorable for survival.	
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Juvenile dependence on groundwater exchange is a data gap; however, loss of thermal refuge may decrease the availability of suitable rearing habitat, leading to decreased growth and fitness. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations) if	
	Marine		1				potential spawning habitat is affected	l
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Adults	<u>Adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing marine food web productivity and availability of prey species. This could lead to decreased adult growth and fitness, however incremental effects may not be significant considering the wide	Care and mag proc Enc desi
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent			sedi patte curr
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		ranging marine habitats of adult sturgeon.	

Minimization Measures	Resulting Effects of the Submechanism
Annulization Measures annel geometry, flow velocity, ostrate composition, and bundwater exchange to the greatest tent practicable.	Submechanism
refully evaluate project siting d design and consider the agnitude of impact mechanisms oduced by the project. acourage selections of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and rrent patterns.	May affect adult growth and fitness.

HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon. Table A-14 (continued).

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tivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous			
	Lacustrine	1	I	1	1			
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Care and mag proo Enc desi
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of juvenile rearing habitat. This may occur through increased predation exposure, food web alterations,	sedi patt curr
	Altered sediment supply Altered substrate composition		Year-round Year-round	Permanent	Continuous		and decreased foraging opportunity. Alteration of current and circulation patterns may prevent larvae transport to suitable rearing environments. The combined effect of these stressors can result in decreased survival, growth, and fitness at larval and juvenile life-history stages. <u>Adults</u> : Adult sturgeon are generally less sensitive to these stressors. However, food web productivity in large reservoir environments may be affected by these impact mechanisms. This could lead to reduced adult foraging opportunities in residualized populations, and decreased growth, fitness, and spawning productivity.	
	Ecosystem Fragmentation							
	Riverine							
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Larvae; Juveniles;	Larvae and juveniles: See related stressor responses under Water Quality Modification.	Req hyd befo

Minimization Measures	Resulting Effects of the Submechanism
arefully evaluate project siting d design and consider the agnitude of impact mechanisms oduced by the project. acourage selections of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and rrent patterns.	May affect survival at larval life- history stage. May affect growth and fitness at juvenile life-history stage. May affect adult growth and fitness, and adult spawning productivity.
equire assessment of the draulic effects of the project fore permitting.	See effects for related stressors under Water Quality Modification.

Sub-											
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor				
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.				
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off- channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : LWD removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of larval sturgeon rearing habitat. Decreased habitat availability may lead to density-dependent effects on larval and juvenile survival, growth, and fitness.	Requ hydr befor perm disco habit			
	Altered longitudinal habitat connectivity	Reduced availability of suitable habitats along longitudinal gradient.									
	Marine		1		4						
	Altered terrestrial/aquatic connectivity Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability		Year-round Permanent		Continuous	Juveniles	All exposed life-history stages: LWD removal in the marine environment could possibly fragment nearshore habitat. Sturgeon dependence on these habitat types is currently a data gap; therefore, the effects of this stressor are unknown.	Requ footp objec in are effect			
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Enco perm habita			
	Lacustrine						•	1			
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : LWD removal in lacustrine environments can fragment nearshore habitat, forcing foraging larval and juvenile sturgeon to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Requi footp objec in are effect			
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encor perma habita			
	Aquatic Vegetation Modification										
	Marine										
	Altered autochthonous	Reduced food web productivity	Year-round (most	Permanent	Continuous	Adults	Adults: Adult sturgeon dependence on	Const			

Minimization Measures	Resulting Effects of the Submechanism
	May affect survival, growth, and fitness of juveniles and adults.
Require assessment of the ydraulic effects of the project efore permitting, and avoid ermitting designs that lead to isconnection of floodplain abitat.	May affect survival at egg, larvae, and juvenile life-history stages. May affect spawning productivity.
tequire structures with the minimal potprint necessary to achieve project bjectives. Avoid permitting projects n areas where significant cumulative ffects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
Encourage project designs that limit ermanent alteration of high-quality abitat features.	May affect juvenile survival.
equire structures with the minimal potprint necessary to achieve project bjectives. Avoid permitting projects n areas where significant cumulative ffects are already prevalent.	May affect survival at juvenile life- history stage. Decreased fitness may lead to reduced spawning productivity
Encourage project designs that limit ermanent alteration of high-quality abitat features.	May affect juvenile survival.
Construction: Avoid/minimize	May affect adult growth and fitness.

Sub-												
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	production		pronounced in spring and summer when vegetation growth is most extensive)				nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	distu durii				
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	<u>Adults</u> : Adult sturgeon dependence on nearshore habitat complexity is limited. However, effects on habitat complexity may limit the availability and productivity of prey species; therefore, this stressor could indirectly affect adult growth and fitness. Given the extended marine foraging habitats used by sturgeon, localized effects are likely to be insignificant.					
	Riverine and Lacustrine	Riverine and Lacustrine										
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	<u>Con</u> distu durin				
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Reduced aquatic habitat complexity may limit the availability of suitable refuge and foraging habitat, leading to increased predation exposure and decreased foraging opportunities, affecting survival, growth, and fitness.					
	Riparian Vegetation Modification											
	Riverine											
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality of embryos at temperatures in excess of 68°F (20°C). Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns. Decreased growth when exposed to temperatures in excess of 75°F (24°C). <u>Adults</u> : Exposure to thermal barriers is unlikely as spawning migrations occur in mid- to late-winter and spawning occurs in turbulent river mainstems.	Avo ripar appr the g				

Minimization Measures sturbance of aquatic vegetation ring project construction.	Resulting Effects of the Submechanism However, localized effects are likely to be insignificant.
instruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	May affect juvenile productivity. May affect juvenile survival, growth, and fitness.
roid/minimize disturbance of arian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible	May affect survival, growth, and fitness during incubation, rearing, and spawning.

HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

b-			Ex	posure	ſ	ŕ			Desculture Fifth days 6 the
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles;	Eggs and larvae: Decreased incubation success and larval survival due to effects of turbidity exposure as described above under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival during incubation larval dispersal, as well as survival, growth, and fitness during juvenile rearing.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sturgeon dependence on groundwater exchange is currently a data gap. However, juveniles are dependent on water temperatures less than 75°F (24°C) for optimal growth. Reduction in thermal refuge habitat may lead to avoidance behavior, decreased growth, and decreased fitness.	Avoid disturbance of vegetation along stream.	Effects of action resulting from this impact mechanism are unknown, as sturgeon dependence on groundwater-surface water exchange is a data gap. However, loss of thermal refuge habitat may affect juvenile growth and fitness.
	Marine				[T			
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Adults	<u>Adults</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of stressor exposure on adult sturgeon are expected to be insignificant and discountable.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Adults	<u>Adults:</u> Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of stressor exposure on adult sturgeon are expected to be insignificant and discountable.

Table A-14	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

			Ex	posure	1	1			
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Adults	<u>Adults</u> : Sturgeon dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap; therefore, the effects of the action from this impact mechanism are unknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	<u>Adults:</u> Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Encourage project designs that limit permanent alteration of high- quality habitat features.	Effects of stressor exposure on adult sturgeon are expected to be insignificant and discountable.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Adults	<u>Adult</u> : Sturgeon dependence on groundwater inflow to nearshore marine habitats is currently a data gap. However, adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap; therefore, the effects of the action from this impact mechanism are unknown.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of turnover time, stratification patterns, wind conditions, and other factors. However, the suitability of some protected habitats such as isolated embayments may be affected, leading to decreased rearing habitat availability and increased competition, leading to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sturgeon dependence on allochthonous inputs from lacustrine riparian vegetation is a data gap. However, juvenile sturgeon are opportunistic feeders. Loss of terrestrial insect-fall could lead to decreased foraging opportunities, affecting growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high- quality habitat features.	May affect juvenile growth and fitness.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Sturgeon dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap. However, juveniles are dependent on water temperatures less than 75°F (24°C) for optimal growth. Reduction in thermal refuge habitat may lead to avoidance behavior, decreased growth, and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects of action resulting from this impact mechanism are unknown, as sturgeon dependence on lacustrine groundwater inflow is a data gap. However, loss of thermal refuge habitat may affect juvenile growth and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.

			Ex	posure			_		
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of all exposed life-history stages.
A	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Physiological responses to exposure at levels exceeding tolerance thresholds, causing mortality or injury leading to reduced fitness. Avoidance behavior during subacute events.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of incubating eg and larvae. May affect juvenile and adult survival, growth, and fitness.
n	ing Substrate Aug Construction and Maintenance Activities	mentation							
ļ	Riverine					1	1		
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life history stages.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Juveniles</u> : Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. <u>Adults</u> : May cause avoidance behavior. Note: While these responses are	Although, little is known about the effects of anthropogenic sounds on sturgeon, it is prudent to avoid/ minimize noise intensity during inwater work.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects a unknown as stressor sensitivity is currently a data gap.

Riverine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Refue contr water work
	Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles:Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness.Adults:May cause avoidance behavior.Note:While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Altho effect sturge minir water

			Ех	posure	.			
v ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avo ripar shor prop
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles;	Eggs and larvae, juveniles: Injury or mortality from burial during gravel placement.	Rest perio larva likel
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Lin grea

HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of parian vegetation. Limit bank, preline and benthic disturbance. Use oper erosion control BMPs.	See effects for related stressors under Water Quality Modification
estrict in-water work window to riods when incubating eggs and vae with limited motility are least ely to be present.	May cause direct mortality or injury at egg, larvae, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
mit area of dewatering to the eatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Sub-			Ex	posure	1	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Eggs and larvae; Juveniles Adults	Eggs and larvae: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation. Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success, and potentially increased predation exposure. Changes in flow regime may cause larvae to be transported to environments unfavorable for survival.	Ensure that project has been designed properly for ecosystem context.	May affect survival at egg and larval life-history stages. May affect juvenile growth and fitness. May affect adult spawning productivity.
						0	Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Juvenile dependence on groundwater exchange is a data gap; however, loss of thermal refuge may decrease the availability of suitable rearing habitat, leading to decreased growth and fitness.		
							<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations) if potential spawning habitat is affected		
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and larvae; Juveniles Adults	Eggs and larvae: Changes in substrate composition and stability may lead to decreased incubation success and larvae survival while augmentation projects stabilize. Juveniles: Altered channel geometry, bank	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize	May affect survival at egg, larvae, and juvenile life-history stages. May affect spawning productivity.

		I	Exposure	r	Ţ		
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Altered substrate composition/stability			Short-term to long- term			stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	adve bank to th
Aquatic Vegetation Modification							
Riverine							
Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoi proje veget habit
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Reduced aquatic habitat complexity may limit the availability of suitable refuge and foraging habitat, leading to increased predation exposure and decreased foraging opportunities, affecting survival, growth, and fitness.	
	Altered substrate composition/stability Aquatic Vegetation Modification Riverine Altered autochthonous production	Altered substrate composition/stability Altered substrate composition/stability Aquatic Vegetation Modification Aquatic Vegetation Modification Riverine Altered autochthonous production Reduced foraging opportunities Production Altered habitat complexity Reduced food web productivity, reduced foraging opportunity,	Mechanism of Impact Stressor When Altered substrate composition/stability Image: Composition (Stability) Image: Composition (Stability) Image: Composition (Stability) Aquatic Vegetation Modification Image: Composition (Stability) Image: Composition (Stability) Image: Composition (Stability) Aquatic Vegetation Modification Reduced foraging opportunities Year-round Altered autochthonous production Reduced foraging opportunities Year-round Altered habitat complexity Reduced foraging opportunity, reduced foraging opportunity, Year-round	Mechanism of Impact Stressor When Duration Altered substrate composition/stability Short-term to long- term Short-term to long- term Aquatic Vegetation Modification Reduced foraging opportunities Year-round Short-term to permanent (dependent on nature of activity) Altered habitat complexity Reduced foraging opportunity, reduced foraging opportunity,	Mechanism of Impact Stressor When Duration Frequency Altered substrate composition/stability Short-term to long- term Short-term to long- term Short-term to long- term Aquatic Vegetation Modification Reduced foraging opportunities Year-round Short-term to permanent (dependent on nature of activity) Continuous Altered habitat complexity Reduced food web productivity, reduced foraging opportunity, reduced foraging opportunity, Year-round Short-term to permanent (dependent on nature of activity) Continuous	Mechanism of Impact Stressor When Duration Frequency Life-history Form Altered substrate composition/stability Short-term to long- term Short-term Image: Short-term Short-term Aquatic Vegetation Modification Automatic Vegetation Short-term Image: Short-term Image: Short-term Aquatic Vegetation Modification Reduced foraging opportunities Year-round Short-term to permanent (dependent on nature of activity) Continuous Juveniles Altered habitat complexity Reduced forod web productivity, reduction in analable cover Year-round Short-term to permanent (dependent on nature of activity) Continuous Juveniles	Mechanism of Impact Stressor When Duration Frequency Life-history Form Response to Stressor Altered substrate composition stability Image: Stressor Short-term to long- term Image: Stressor Short-term to long- term Image: Stressor Response to Stressor Altered substrate Image: Stressor Short-term to long- term Image: Stressor Response to Stressor stability, and subcrate composition can result in short-term to image: Stressor Autered substrate Image: Stressor Image: Stressor Image: Stressor Response to Stressor Autered substrate Image: Stressor Image: Stressor Image: Stressor Response to Stressor Autered substrate Image: Stressor Image: Stressor Image: Stressor Image: Stressor Autered substrate Image: Stressor Image: Stressor Image: Stressor Image: Stressor Modification Resource Image: Stressor Image: Stressor Image: Stressor Autered substhifts of Coresponder production on suitable in Coresponder production on suitable in coresponder production on productin on production on production on productin on productio

Resulting Effects of the Submechanism
May affect juvenile survival, growth, and fitness.

Sub-			Ех	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
In-Cha	Altered suspended solids Altered suspended solids annel/Off-Channel Construction and Maintenance Activities	Increased suspended solids Habitat Creation/Modific	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality of injury in acute events.
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses described for related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life history stages.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Juveniles</u> : Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. <u>Adults</u> : May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Although, little is known about the effects of anthropogenic sounds on sturgeon, it is prudent to avoid/ minimize noise intensity during in- water work.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification

ub-			Ex	posure	r				
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Juveniles and larvae</u> : Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to larvae and juveniles. Stress from relocation may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Larvae and juveniles</u> : Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. <u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : May cause avoidance behavior, potentially delaying migration.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg and larval life-history stages. May affect juvenile survival, growth, and productivity. May cause adult avoidance behavior, potentially delaying migration and limiting spawning productivity; however, actual sensitivity to these stressors is a data gap.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Non-mobile eggs and larvae may experience injury or mortality from dredge entrainment. Juveniles and adults: Decreased growth and fitness due to stress and exertion caused by avoidance behavior and decreased foraging opportunity caused by short-term reduction in prey availability. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May cause direct injury or mortality of eggs and larvae. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.

HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-			Ex	oosure						
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.	
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of all exposed life-history stages.	
Ripari	an Planting/Restor	ation Enhancement								
	Maintenance Activities									
	Riverine , Lacustrine, Marine									

Construction and Maintenance Activities
Riverine , Lacustrine, Marine

			Ex	posure					
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality of embryos at temperatures in excess of 68°F (20°C). Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns. Decreased growth when exposed to temperatures in excess of 75°F (24°C). <u>Adults</u> : Exposure to thermal barriers is unlikely as spawning migrations occur in mid- to late-winter and spawning occurs in turbulent river mainstems.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during incubation, rearing, and spawning.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification
		Spawning gravel sedimentation – due to removal of invasive riparian species							
	Aquatic Vegetation Modification				I				
_	Riverine and Lacustrine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile productivity.

			Ex	posure					
v ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Adults	<u>Adults</u> : Adult sturgeon dependence on nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect adult growth and fitness. However, localized effects are likely to be insignificant.
	Riparian Vegetation Modification								
	Riverine and Lacustrine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon allochthonous material; reducing allochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile productivity.
	Marine		·				•		•
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Adults	<u>Adults</u> : Adult sturgeon dependence on nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect adult growth and fitness. However, localized effects are likely to be insignificant.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality of embryos at temperatures in excess of 68°F (20°C). Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns. Decreased growth when exposed to temperatures in excess of 75°F (24°C). <u>Adults</u> : Exposure to thermal barriers is unlikely as spawning migrations occur in mid- to late-winter and spawning occurs in turbulent river mainstems.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during incubation, rearing, and spawning.

ıb- tivity			Ex	posure						
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivi and spawning success. May caus direct mortality or injury in acute events.	
lar	Construction and Maintenance Activities	ation/Enhancement								
lan	Construction and Maintenance Activities Riverine and Marine									
lan	Construction and Maintenance Activities	ation/Enhancement	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life history stages.	

HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

)- ivity			Ex	posure					Resulting Effects of the
e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Juveniles and larvae</u> : Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury t larvae and juveniles. Stress from relocation may affect survival, growth and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Larvae and juveniles</u> : Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.
		Benthic disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. <u>Juveniles</u> : Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : May cause avoidance behavior, potentially delaying migration.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg an larval life-history stages. May affect juvenile survival, growth, and productivity. May cause adul avoidance behavior, potentially delaying migration and limiting spawning productivity; however, actual sensitivity to these stressors is a data gap.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Sub- activity			Ex	posure						
-	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
Altered suspended	solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivit and spawning success. May cause direct mortality or injury in acute events.	
Altered Pollutant L		Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of all exposed life-history stages.	
ch Nourishment		ouring								
Construction and Maintenance Activ										
Lacustrine										
Equipment Operation	on	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life history stages.	
Bank, channel, shor disturbance	reline	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.	

Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Ref con wat wor
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Ave proc

Sub-Exposure activity **Mechanism of Impact** Stressor When Duration Frequency Life-history Form **Response to Stressor** Туре Hvdraulic and **Geomorphic Modification** Lacustrine Altered sediment supply Localized alteration in invertebrate During project Short-term - long-Interannual to Juveniles Juveniles: Short-term reduction in foraging Av abundance from burial construction and decadal (depending opportunity, increased competition, decreased pro term maintenance activities on activity growth and fitness. cor frequency) Aquatic Vegetation Modification Lacustrine Juveniles Juveniles: Juvenile sturgeon are known Altered autochthonous Reduced foraging opportunities and Year-round Short-term to long-Continuous Av to feed opportunistically upon benthic rearing habitat availability term(dependent on production veg prey organisms and fish dependent upon Av nature of activity) autochthonous material; reducing pro Altered cover and habitat Reduced cover autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Water Quality Modification Eggs and larvae: Turbidity may lead to En Altered suspended solids Increased suspended solids During construction Temporary to short-Intermittent to Eggs and larvae; direct mortality and decreased survival of and during subsequent term (dependent on interannual-decadal and Juveniles: eggs and larvae. Green sturgeon eggs alt high energy periods grain size of (dependent on Adults lack thick jelly coat of other sturgeon ins augmented sediment) contributing species and develop more rapidly, tur mechanism of lev indicating greater sensitivity to acute impact) turbidity. pra pro Juveniles and adults: Responses vary and depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Minimization Measures	Resulting Effects of the Submechanism
void project site which are roductive and have a healthy benthic ommunity.	May affect growth and fitness at juvenile life-history stage.
void/minimize disturbance of aquatic egetation during project construction. void nourishing beaches updrift of roductive, vegetated aquatic habitat.	May affect juvenile productivity.
nsure that project design avoids nd/or minimizes habitat Iterations leading to chronic bank astability. Avoid short-term arbidity effects above background evels to greatest extent racticable. Adhere to established rotocols for managing sediment nd turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of all exposed life-history stages.
Reef C	reation/Restoration	n/Enhancement							
	Construction and Maintenance Activities								
	Marine and Lacustrine			1			1		1
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Juveniles</u> : Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. <u>Adults</u> : May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Although, little is known about the effects of anthropogenic sounds on sturgeon, it is prudent to avoid/ minimize noise intensity during in- water work.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Adults	<u>Adults</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on	May affect adult growth and fitness. Actual effects are unknown as stressor sensitivity is currently a data gap.

HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		parameters can fundamentally alter marine littoral habitats, potentially decreasing marine food web productivity and availability of prey species. This could lead to decreased adult growth and fitness, however incremental effects may	sedin patte curre
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		not be significant considering the wide ranging marine habitats of adult sturgeon.	
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous			
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous			
	Lacustrine		1 -					1
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Care and mag prod Enco desig
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous		or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of juvenile rearing habitat. This may occur through increased predation exposure, food web alterations,	sedi patte curr
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		and decreased foraging opportunity. Alteration of current and circulation patterns may prevent larvae transport to suitable rearing environments. The	
	Altered sediment supply	J	Year-round	Permanent	Continuous		combined effect of these stressors can	

Minimization Measures diment supply, longshore drift tterns, and wave energy and rrent patterns.	Resulting Effects of the Submechanism
rrefully evaluate project siting d design and consider the agnitude of impact mechanisms oduced by the project. acourage selections of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and rrent patterns.	May affect survival at larval life- history stage. May affect growth and fitness at juvenile life-history stage. May affect adult growth and fitness, and adult spawning productivity.

Table A-14 (continued).HPA HC

Mechanism of Impact			Exposure	1		-	
· · · · · · · · · · · · · · · · · · ·	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
ered substrate nposition		Year-round	Permanent	Continuous		result in decreased survival, growth, and fitness at larval and juvenile life-history stages. <u>Adults</u> : Adult sturgeon are generally less sensitive to these stressors. However, food web productivity in large reservoir environments may be affected by these impact mechanisms. This could lead to reduced adult foraging opportunities in residualized populations, and decreased growth, fitness, and spawning productivity.	
osystem Fragmentation							
custrine		1			• 		
ered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avo prox corr pred
uatic Vegetation odification							
arine							
ered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	<u>Adults</u> : Adult sturgeon dependence on nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	Avo
custrine							
ered autochthonous duction ered cover and habitat	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting	Avo vege
	system Fragmentation ustrine ered cover and habitat natic Vegetation dification rine ered cover and habitat	system Fragmentation ustrine ustrine rered cover and habitat Increased predation by piscivorous fish trine rered cover and habitat Decreased refuge and forage habitat Ustrine ustrine ustrine rered autochthonous tuction Reduced foraging opportunities	system Fragmentation ustrine ered cover and habitat Increased predation by piscivorous fish Year-round natic Vegetation diffication rine ered cover and habitat Decreased refuge and forage habitat Year-round natic Vegetation Decreased refuge and forage habitat Year-round natic Vegetation Reduced foraging opportunities Year-round	system Fragmentation ustrine red cover and habitat Increased predation by piscivorous fish Year-round Permanent natic Vegetation diffication rine red cover and habitat Decreased refuge and forage habitat Year-round Short-term to permanent (dependent on nature of activity) ustrine red autochthonous huction Reduced foraging opportunities Year-round Short-term to permanent (dependent on nature of activity)	system Fragmentation ustrine red cover and habitat Increased predation by piscivorous fish Year-round Permanent Continuous natic Vegetation diffication Permanent Continuous natic Vegetation Decreased refuge and forage habitat Year-round Short-term to permanent (dependent on nature of activity) red cover and habitat Decreased refuge and forage habitat Year-round Short-term to permanent (dependent on nature of activity) ustrine	system Fragmentation system Fragmentation system Fragmentation system Fragmentation ustrine read cover and habitat Increased predation by piscivorous fish Year-round Permanent ratic Vegetation differation differation Juveniles read cover and habitat Decreased refuge and forage habitat Year-round Short-term to permanent (dependent on nature of activity) Continuous Adults sustrine vear-round Short-term to permanent (dependent on nature of activity) Continuous Juveniles ustrine vear-round Short-term to permanent (dependent on nature of activity) Continuous Juveniles	and the second secon

Minimization Measures	Resulting Effects of the Submechanism
void placement of reef projects in oximity to juvenile migratory rridors, such that increased edation exposure may occur.	May affect juvenile survival, growth and fitness.
void/minimize disturbance of aquatic getation during project construction.	May affect adult growth and fitness. However, localized effects are likely to be insignificant.
oid/minimize disturbance of aquatic getation during project construction.	May affect juvenile productivity.

Type Medaname Omegana (stream) Outcome (stream) Outcom) Outcome (stream) Outcom)	Sub-			Ex	posure					
Altered polutate loading Lasching of twice substances (dependitor on mechanism of impact) Continueues unchanism of impact) Continueues mechanism of impact) Continueues with controls and actual (dependitor on mechanism of impact) Jaccanlog, with controls and actual (mechanism of impact) Jaccanlog, with controls and with control on any with controls and with controls and with controls and with control on any with controls any with controls any with controls any with contr	activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
(depending on composition of reef material) (depending on composition of reef material) seasonal pulses (dependent on current velocity) Juveniles; Adults Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. drastically reduce hydraulic complexity or impact riparian buffers. fitness of all exposed life-history stages. Bioaccumulation of contaminants at subacute levels, resulting to reduced fitness. Due to their long lifespan and high age t maturity, adult strey on and high age to contaminants. Chronic exposure to contaminants and spawning productivity. fitness, and spawning productivity. fitness, and spawning productivity. fitness, and spawning productivity.		Altered suspended solids	Increased suspended solids	contributing	term (dependent on contributing mechanism of	interannual–decadal (dependent on contributing mechanism of	Juveniles;	direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation	and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment	larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute
Eel Grass and Other Aquatic Vegetation			(depending on composition of reef material)	Year-round	Intermediate-term	seasonal pulses (dependent on	Juveniles;	Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning	drastically reduce hydraulic	fitness of all exposed life-history
		No negative impa	cts.							

HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

ty			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
er	Dam Removal								
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, grow and fitness of juveniles and adults
-		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Unlikely to affect smelt population when activities are conducted in prescribed in-water work windows avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae: Channel dewatering will cause egg mortality. Juveniles: Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. <u>Adults</u> : Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larva and juveniles is impractical, mean that activities occurring during incubation and emigration periods affect survival during these life-his stages. Capture and removal of ad are likely to affect survival and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	Not likely to affect smelt at any lit history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors ur Water Quality Modification.

			Ex	posure							
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Hydraulic and Geomorphic Modification			-	-						
	Riverine										
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring	May affect survival at egg and lan life-history stages. May affect spawning productivity.		
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit	flows. Encourage use of beaver deceivers.			
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal		foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous		<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable				
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous		resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of XXX) if potential spawning habitat is affected.				
	Ecosystem Fragmentation										
	Riverine										
	flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and docay is	Permanent	Seasonal	Eggs; Larvae;	Eggs and larvae: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressor under Water Quality Modifica		
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export) growth and decay is most extensive)	most extensive)								
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs; Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, a fitness of juveniles and adults.		

			Ех	posure					
ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Permanent	Continuous	Larvae; Adults	<u>Adults</u> : LWD removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt. Planktonic larvae are carried downstream to estuarine habitats, and are not dependent on floodplain habitats.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, larvae, and juvenile life-history stages. May affect spawning productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Eggs; Larvae;	<u>All exposed life-history stages</u> : Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap.	Avoid draining impounded area through use of beaver deceivers.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects
	Altered cover and habitat					Adults	Therefore, the potential for exposure to these stressors is unknown.		resulting from this impact mechanism are unknown.
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	Eggs and larvae: Decreased incubation success due to smothering of eggs as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival during egg incubation; may affect spawning fitness and productivity.
		Spawning gravel sedimentation					turbidity as described for related stressor responses under Water Quality Modification.		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Larvae	Larvae: Larval longfin smelt and eulachon feed on forage on riverine plankton following emergence and transport to estuarine and marine habitats. Reduced allochthonous inputs may affect food web productivity, leading to decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect larval growth and fitness.

			Ex	posure		,			
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modificatio
Ī	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. <u>Juveniles</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg May affect juvenile productivity, adu productivity, and spawning success.
-	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival and productivity of eggs, larvae, and juveniles
-	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved events due to asphyxiation. <u>Juveniles and adults</u> : Avoidance behavior and increased stress, leading to reduced growth and fitness.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of incubating egg May affect juvenile survival and productivity and adult survival, productivity, and spawning success.

			Ex	posure	·			Deculting Effects of the	
y N	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	onstruction and aintenance Activities		-	-	-	-	-	-	-
	verine, Lacustrine, arine								
Equ	uipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, grow and fitness of juveniles and adults
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	 Eggs and larvae: Noise of sufficient magnitude may cause direct mortality of eggs and larval smelt or permanent injury leading to decreased survival and fitness. Adults and juveniles: Stressor response, depending on noise magnitude and project-specific environmental conditions, may range from: Fatal injury or permanent auditory tissue damage limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey. Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to system-specific in- water work windows to avoid stressor exposure during spawning, incubation, and larval dispersal (November to April, depending on system). If pile driving is necessary during spawning period, use double-confined bubble curtain to attenuate sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Unlikely to affect smelt populations when activities are conducted in prescribed in-wa work windows, avoiding spawning, incubation, and lary dispersal. The potential for juvenile exposure is less well known. Except for the landloo Lake Washington population of longfin smelt, juvenile habitat by these species is poorly understood. Subadults are known to migrate to offshore areas on continental shelf.
	nk, Channel, Shoreline sturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors un Water Quality Modification.

)-			Ex	osure	-				
vity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae: Channel dewatering will cause egg mortality. Juveniles: Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. <u>Adults:</u> Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larvae, and juveniles is impractical, meaning that activities occurring during incubation and emigration periods ma affect survival during these life-histor stages. Capture and removal of adult are likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities ar conducted outside in-water work windows. If activities are permitted during in-water work windows, activity may affect adult and egg and larval survival. The potential for effects on juvenile smelt survival in marine habitats and Lake Washington are unknown because habitat use by this life-history stage is a data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. <u>Adults</u> : Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, increased predation exposure, decreased spawning habitat suitability.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	Unlikely to affect egg survival an adult spawning productivity wher activities are conducted during in- water work windows. May affect these parameters if activities occu during spawning and incubation.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.		Not likely to affect smelt at any life- history stage.

b-			Ex	posure						
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	<u>Eggs</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at egg and larval life-history stages. May affect spawning productivity.	
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Permanent	Seasonal	nal	Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.		
	Altered substrate composition	_	Year round	Permanent	Continuous		foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and			
	Altered groundwater- surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous		survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of XXX) if potential spawning habitat is affected.			
	Marine		l				L			
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Longfin smelt and eulachon dependence on these habitats is currently a data gap. However, alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival, growth, and fitness at the larval and juvenile life- history stages. Decreased fitness may affect survival and productivity durin ocean migration life-history phase, an may affect spawning productivity.	
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent			patterns, and wave energy and current patterns.		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous					

-			Ex	posure			_		
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		have concomitant effects on food web relationships in the offshore environment. <u>Adults</u> : Alteration of nearshore habitat parameters may affect survival and foraging opportunities at larval and juvenile life-history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.		
	Lacustrine	1	1	1	I			1	1
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles;	Larvae, juveniles, and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect productivity at larval and juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common	Adults	or more of these parameters can fundamentally alter lacustrine littoral habitats, with concomitant food web effects throughout the lacustrine ecosystem. Therefore, alteration of these parameters may affect foraging opportunities for longfin smelt at larval	patterns, and wave energy and current patterns.	
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous		and juvenile life-history stages, leading to decreased adult fitness and decreased spawning success.		
	Ecosystem Fragmentation						I		
	Riverine								
Riverine Altered hyp	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Unknown	Longfin smelt and eulachon dependence on groundwater exchange is currently a data gap.	Require assessment of the hydraulic effects of the project before permitting.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs; Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

				Exposure	r	1			
М	Iechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
(terr habi	1	Reduced availability of off- channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Adults	<u>Adults</u> : LWD removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt. Planktonic larvae are carried downstream to estuarine habitats, and are not dependent on floodplain habitats.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival at egg, larva and juvenile life-history stages. May affect spawning productivit
conn	nectivity	habitats along longitudinal gradient.							
Mar	rine								
	ered terrestrial/aquatic nectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juvenile; Adult	<u>All exposed life-history stages</u> : LWD removal in the marine environment can fragment nearshore habitat. Eulachon and longfin smelt are known to use these habitat types during juvenile and adult life-history stages, and are likely to occur as larvae as well. LWD removal may alter migration of adults toward spawning habitats, larval dispersal, and juvenile foraging, affecting survival, growth, and fitness at all life-history stages.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-histo stage. Decreased fitness may affect survival and productivity during ocean migration life-histo phase.
Alter	ered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
Lacu	custrine							•	
	nectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt dependence on nearshore habitats in Lake Washington is currently a data gap. Therefore the effects of this stressor are unknown.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
Alter		Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
_	atic Vegetation dification				1	1			

Mechanism of ImpactStressorWhenDurationFrequencyLife-history FormResponse to StressorAllered autochthonous productionAllered autochthonous productionReduced food web productivityYear-round (most pronounced in spring and summer when vegetation growth is most extensive)PermanentContinuousLarvae; huveniles; AdultsAll exposed life-history stages: Longf smelt and eulachon dependence on nearshore marine environment is currently a data gap. Therefore, the pronounced in spring and summer when vegetation growth is most extensive)PermanentSeasonalJuveniles; adultsAll exposed life-history stages: Longf smelt and eulachon dependence on nearshore marine environment is currently a data gap. Therefore, the pronounced in spring and summer when vegetation growth is most extensive)Permanent (dependent on nature of activity)Juveniles; AdultsAll exposed life-history stages: Longf smelt and eulachon dependence on marine liftoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potation dependence on marine liftoral vegetation and the most extensive)Altered nabitat complexity reduction in available coverYear-round (most permanent (dependent on nature of activity)ContinuousLarvae; Larvae; AdultsAll exposed life-history stages: Longf adultsHered autochhonous productionReduced food web productivity reduced forging opportunity, reduced for orging opportunity, reduced for adultsYear-round (most permanent (dependent on nature of activity)ContinuousLarvae; AdultsAll exposed life-history s	distu duri
production pronounced in spring and summer when vegetation growth is most extensive) pronounced in spring and summer when vegetation growth is most extensive) Juveniles; Adults smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stresson under Water Quality Modification. Altered habitat complexity reduced food web productivity, reduced for againg opportunity, reduction in available cover Year-round (most permanent (dependent on nature of activity) Seasonal Juveniles All exposed life-history stages: Long smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stresson under Water Quality Modification. Altered habitat complexity reduced foraging opportunity, reduction in available cover Year-round Short-term to permanent (dependent on nature of activity) Continuous Larvae; Juveniles; Adults All exposed life-history stages: Long smelt and eulachon dependence on margine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stresson unknown. Reverine and Lacustrine Fermanent Continuous Eggs; Larvae; Adults All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation growth is	distu duri
reduced photosynthesispronounced in spring and summer when vegetation growth is most extensive)pronounced in spring and summer when vegetation growth is most extensive)under Water Quality Modification.Altered habitat complexityReduced food web productivity, reduced foraging opportunity, reduction in available coverYear-roundShort-term to permanent (dependent on nature of activity)ContinuousLarvae; Juveniles; AdultsAll exposed fife-history stages: Long smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stressor unknown.Riverine and LacustrineReduced food web productivity productionYear-round (most pronounced in spring and summer when vegetation growth isPermanent continuousContinuous Eggs; Larvae; AdultsAll exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressor unknown.	
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production pronounced in spring and summer when vegetation growth is dependence on freshwater submerged Adults dependence on freshwater submerged aquatic vegetation is currently a data g Therefore, the potential for exposure to	
	<u>Con</u> distr o. duri
Altered dissolved oxygen levels due to reduced photosynthesis Year-round (most pronounced in spring and summer when vegetation growth is most extensive) Permanent Seasonal Juveniles Juveniles and adults: See related stressor responses under Water Quality Modification	
Altered habitat complexityReduced food web productivity, reduced foraging opportunity, reduction in available coverYear-roundShort-term to permanent).
Riparian Vegetation Modification	
Riverine	

Minimization Measures	Resulting Effects of the Submechanism
onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	See effects for related stressors under Water Quality Modification.
	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	See effects for related stressors under Water Quality Modification.
	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.

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ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Adults	<u>Adults</u> : Decreased spawning productivity and fitness due to migration delays caused by low water temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible	May affect spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	Eggs and larvae: Decreased incubation success due to smothering of eggs as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival during egg incubation; may affect spawning fitness and productivity.
		pools)				0	<u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.		
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	<u>Adults:</u> Reduced habitat complexity may affect the availability of suitable spawning habitat leading to decreased spawning productivity.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect adult spawning productivity.
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Unknown	Longfin smelt and eulachon dependence on groundwater exchange is currently a data gap.	Avoid disturbance of vegetation along stream.	Sensitivity to stressor exposure currently a data gap for these species; therefore, the potential effects resulting from this impa mechanism are unknown.
	Marine							·	
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Larvae; Juveniles	Larvae and juveniles: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Dependence of larval and juvenile longfin smelt and eulachon on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these spec- therefore, the potential effects resulting from this impact mechan are unknown.

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vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	Larvae and juveniles: Dependence of larval and juvenile longfin smelt and eulachon on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these specie therefore, the potential effects resulting from this impact mechanis are unknown.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Longfin smelt and eulachon dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these specie therefore, the potential effects resulting from this impact mechanis are unknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles	<u>Larvae and juveniles</u> : Dependence of larval and juvenile smelt on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Dependence of larval and juvenile smelt on surface water and groundwater exchange in nearshore habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid disturbance of vegetation along shoreline.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Lacustrine		·			•			·
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Riparian shade and ambient temperature has a relatively minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade. Dependence of juvenile longfin smelt on these habitats is currently a data gap Therefore the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Potential habitat avoidance and/or injury/mortality caused by excessive turbidity, potential for decreased foraging success leading to decreased growth and fitness as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival and productivity.

			Ex	posure	i					
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Longfin smelt dependence on allochthonous inputs from lacustrine riparian vegetation is a data gap. Therefore the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from th impact mechanism are unknown.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Dependence of larval, juvenile, and adult longfin smelt on these habitats is currently a data gap, Therefore the potential for exposure to these stressors is unknown.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Potential effects resulting from th impact mechanism are unknown.	
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Longfin smelt dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap. Therefore the potential for exposure to these stressors is unknown.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.	
	Water Quality Modification					1				
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. <u>Juveniles</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg May affect juvenile productivity, adu productivity, and spawning success.	

			Ex	posure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved events due to asphyxiation. <u>Juveniles and adults</u> : Avoidance behavior and increased stress, leading to reduced growth and fitness.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of incubating eg May affect juvenile survival and productivity and adult survival, productivity, and spawning success.
	Maintenance Activities Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growt and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoi ripari shore prope
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles;	Eggs and larvae, juveniles: Injury or mortality from burial during gravel placement.	Restr perio larva likely
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limi great
	Hydraulic and Geomorphic Modification		1					
	Riverine							
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensu prope
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival.	Caret desig impa proje augm

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of parian vegetation. Limit bank, oreline and benthic disturbance. Use oper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
estrict in-water work window to riods when incubating eggs and vae with limited motility are least rely to be present.	May cause direct mortality or injury at egg, larvae, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
mit area of dewatering to the eatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
sure that project has been designed operly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of gmentation projects that minimize	May affect survival at egg and larval life-history stages. May affect spawning productivity.

		E	xposure	·	- <u>r</u>		
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Altered substrate composition/stability			Short-term to long- term			Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of XXX) if potential spawning habitat is affected.	adv ban to t
Aquatic Vegetation Modification							
Riverine					-		—
Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Adults	<u>All exposed life-history stages</u> : Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Ave pro veg hab
Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Adults	<u>All exposed life-history stages</u> : Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	-

Minimization Measures werse effects on channel geometry, ak conditions, and substrate stability the greatest extent practicable.	Resulting Effects of the Submechanism
oid spawning gravel augmentation ojects in locations where aquatic getation plays a strong role in bitat productivity.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. <u>Juveniles</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
In-Cha	Annel/Off-Channel	Habitat Creation/Modific	ation						
	Kiverine	1	1	1		T			
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

Sub-			Exj	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae: Channel dewatering will cause egg mortality. Juveniles: Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. <u>Adults</u> : Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larvae, and juveniles is impractical, meaning that activities occurring during incubation and emigration periods may affect survival during these life-history stages. Capture and removal of adults are likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities are conducted outside in-water work windows. If activities are permitted during in-water work windows, activity may affect adult and egg and larval survival. The potential for effects on juvenile smelt survival in marine habitats and Lake Washington are unknown because habitat use by this life-history stage is a data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae:Potential decreased eggincubation success and larval survivaldue to turbidity exposure and substratedisturbance.Adults:Stress and behavioralmodifications by adult spawners exposedto sediment pulses, migration delay,increased predation exposure, decreasedspawning habitat suitability.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	Unlikely to affect egg survival and adult spawning productivity when activities are conducted during in- water work windows. May affect these parameters if activities occur during spawning and incubation.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable.	Not likely to affect smelt at any life- history stage.

•			Ex	posure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults:</u> Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eg May affect juvenile productivity, ad productivity, and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival and productivity of eggs, larvae, and juveniles
ri	Construction and Maintenance Activities	ration Enhancement							
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Adults	<u>Adults</u> : Decreased spawning productivity and fitness due to migration delays caused by low water temperatures.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect spawning productivity.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	Eggs and larvae: Decreased incubation success due to smothering of eggs as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival during egg incubation; may affect spawning fitness and productivity.

Construction and Maintenance Activities							
Riverine , Lacustrine, Marine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Adults	<u>Adults</u> : Decreased spawning productivity and fitness due to migration delays caused by low water temperatures.	Mini speci assur speci
	Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	Eggs and larvae:Decreased incubationsuccess due to smothering of eggs asdescribed for related stressor responsesunder Water Quality Modification.Adults:Decreased spawning success dueto decreased availability of suitablespawning habitat.Potential, migrationdelay, habitat avoidance, and/or injuryand mortality caused by excessive	Mini spec erosi after

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ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Spawning gravel sedimentation – due to removal of invasive riparian species					turbidity as described for related stressor responses under Water Quality Modification.		
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Larvae	Larvae: Larval longfin smelt and eulachon feed on forage on riverine plankton following emergence and transport to estuarine and marine habitats. Reduced allochthonous inputs may affect food web productivity, leading to decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect larval growth and fitness.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Adults	<u>Adults</u> : Decreased spawning productivity and fitness due to migration delays caused by low water temperatures.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect spawning productivity.

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ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults:</u> Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs May affect juvenile productivity, adult productivity, and spawning success.
etla	Construction and Maintenance Activities	ration/Enhancement							
	Riverine and Marine							T	
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae;	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
						Juveniles; Adults		work within the channel.	and function of juvenines and address.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae: Channel dewatering will cause egg mortality. <u>Juveniles</u> : Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. <u>Adults</u> : Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larvae, and juveniles is impractical, meaning that activities occurring during incubation and emigration periods may affect survival during these life-history stages. Capture and removal of adults are likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities are conducted outside in-water work windows. If activities are permitted during in-water work windows, activity may affect adult and egg and larval survival. The potential for effects on juvenile smelt survival in marine habitats and Lake Washington are unknown because habitat use by this life-history stage is a data gap.

			Ex	posure	1	·			
,	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae:Potential decreased eggincubation success and larval survivaldue to turbidity exposure and substratedisturbance.Adults:Stress and behavioralmodifications by adult spawners exposedto sediment pulses, migration delay,increased predation exposure, decreasedspawning habitat suitability.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	Unlikely to affect egg survival a adult spawning productivity whe activities are conducted during in water work windows. May affect these parameters if activities occ during spawning and incubation
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable.	Not likely to affect smelt at any life history stage.
Water Quality Modification									
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating e May affect juvenile productivity, a productivity, and spawning success
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.

			Ex	posure		r	_				
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Construction and Maintenance Activities										
M	Marine and Lacustrine										
E	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, grow and fitness of juveniles and adults.		
	Bank, channel, shoreline listurbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.		
	Iydraulic and Geomorphic Modification										
Ν	Marine and Lacustrine			-	-						
A	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.		
	Aquatic Vegetation Modification										
N	Marine										
	Altered autochthonous oroduction	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	Sensitivity to stressor exposure is currently a data gap for these spec therefore, the potential effects resulting from this impact mechar		
A	Altered cover and habitat	Reduced cover					currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	productive, vegetaled aquate habitat.	are unknown.		
L	acustrine										
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Eggs; Larvae; Adults	<u>All exposed life-history stages</u> : Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	Sensitivity to stressor exposure is currently a data gap for these spec therefore, the potential effects resulting from this impact mechan		
	Altered cover and habitat	Reduced cover					Therefore, the potential for exposure to these stressors is unknown.	productive, vegetated aquatic habitat.	are unknown.		

ıb-			Ex	posure	1				
tivity 7pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating egg. May affect juvenile productivity, adul productivity, and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival and productivity of eggs, larvae, and juveniles
eef C	reation/Restoration Construction and Maintenance Activities	n/Enhancement							
	Marine and Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable. Limit activities to system-specific in-water work windows where practicable to avoid effects on spawning adults.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawnin disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.

Marine and Lacustrine							
Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Lim prac wind life
Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avo cavi Pron with tech Lim in-w prac spav

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ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
ſ	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival, growth, and fitness at the larval and juvenile life- history stages. Decreased fitness ma affect survival and productivity durin ocean migration life-history phase, a may affect spawning productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		or more of these parameters can fundamentally alter marine littoral habitats. Longfin smelt and eulachon dependence on these habitats is currently a data gap. However, alteration of current velocities and circulation patterns may cause transportation of planktonic	patterns, and wave energy and current patterns.	
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. <u>Adults</u> : Alteration of nearshore habitat		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		parameters may affect survival and foraging opportunities at larval and juvenile life-history stages, leading to decreased adult fitness, decreased		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		survival, and decreased spawning productivity.		
	Lacustrine	-	·			-			
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles;	Larvae, juveniles, and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect productivity at larval and juvenile life-history stage. Decrease fitness may lead to reduced spawnin productivity.

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	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous	Adults	or more of these parameters can fundamentally alter lacustrine littoral habitats, with concomitant food web effects throughout the lacustrine ecosystem. Therefore, alteration of these parameters may affect foraging	patterns, and wave energy and current patterns. For example:	
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal		opportunities for longfin smelt at larval and juvenile life-history stages, leading to decreased adult fitness and decreased spawning success.		
	Altered sediment supply	1	Year-round	Permanent	Continuous	1	spawning success.		
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, gr and fitness.
	Lacustrine			·					
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, gro and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of aquatic vegetation during project construction.	Sensitivity to stressor exposure i currently a data gap for these spo therefore, the potential effects resulting from this impact mecha are unknown.
ľ	Lacustrine			- *	•				
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent	Continuous	Eggs; Larvae;	<u>All exposed life-history stages</u> : Smelt dependence on freshwater submerged	Avoid/minimize disturbance of aquatic vegetation during project construction.	Sensitivity to stressor exposure currently a data gap for these sp
	Altered cover and habitat			(dependent on nature of activity)		Adults	aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.		therefore, the potential effects resulting from this impact mech are unknown.

			E	xposure			_		
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubati eggs. May affect juvenile productivity, adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productive of eggs, larvae, and juveniles
	ass and Other Aqu on/Restoration/En Construction and Maintenance Activities								
ł	Marine					1			.
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Construction and Maintenance Activities										
Marine										
Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhe work			
Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid above exten establ sedim			

)- vity			Ex	posure	r		
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor
er	Dam Removal						
	Not applicable						
çe em co	Woody Debris hent/Movement/Re nstruction impacts	moval (for placement s apply)					
	Construction and Maintenance Activities						
	Marine						
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving).
							 Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due
							 to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.

Table A-16. HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Minimization Measures

Resulting Effects of the Submechanism

Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.

Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery. May affect survival, growth, and fitness of juveniles and adults.

May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-16	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

			Exj	posure	1	1			
rity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors unde Water Quality Modification.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: These life-history stages will be difficult to capture and relocate effectively. <u>Adults</u> : Capture, handling, and relocation is likely to cause mortality, or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Capture/removal of larvae and juveniles is impractical, meaning that these activities are likely to affect larval and juvenile survival. Capture and removal of adults is likely to affe survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause injury and mortality of larvae, juveniles, and adults. Effects are less likely to occur if activities ar conducted outside of spawning seaso
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Surf smelt and sand lance dependence on benthic invertebrates for forage is likely limited but is currently a data gap. Therefore, the potential effects of stressor exposure are unknown.	Limit area of dewatering to the greatest extent practicable.	Potential effects resulting from this impact mechanism are unknown.

Table A-16 (continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

			Ex	posure					
Mechani	nism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Marine		·		·	·		<u> </u>	·	·
Altered way	ave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival at the larval and juvenile life-history stages. May affe juvenile and adult growth and fitness Decreased fitness may affect spawnir productivity.
Altered cur	irrent velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent			patterns, and wave energy and current patterns.	
Altered sed	diment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
Altered sub composition			Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling	Permanent	Continuous				
			due to altered wave and/or current regime, routine grounding, anchor trenching])						
Ecosystem	n Fragmentation								
Marine									
Altered terr connectivity	rrestrial/aquatic ity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: LWD removal in the marine environment can fragment nearshore rearing habitat, forcing larval and juvenile surf-smelt and sandlance to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion. These stressors may affect survival, growth, and fitness. <u>Adults</u> : The geomorphic effect of LWD removal on the upper intertidal zone may eliminate or decrease the suitability of spawning habitat, potentially limiting the spawning productivity of affected	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval and juvenile survival, growth, and fitness. Ma affect adult survival, fitness, and spawning productivity.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Enco perm habit
	Aquatic Vegetation Modification							
	Marine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Alteration or reduction of submerged aquatic vegetation component of beach wrack may affect microclimate conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). <u>All life-history stages</u> : Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Cons distu durin
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Alteration or reduction of submerged aquatic vegetation component of beach wrack may affect microclimate conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). <u>All life-history stages</u> : Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	

Minimization Measures	Resulting Effects of the Submechanism
courage project designs that limit rmanent alteration of high-quality bitat features.	May affect juvenile survival.
onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.
	See effects for related stressors under Water Quality Modification.
	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

			Ex	posure					
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs	Eggs: Surf smelt and sand lance incubation success is demonstrably affected by microclimate conditions in the nearshore environment that are influenced by riparian vegetation. Alteration of riparian vegetation has been demonstrated to reduce egg survival and incubation success.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival, decreasing population productivity.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	Eggs: Smothering of incubating eggs or alteration of substrate composition may decrease egg survival. Larvae and juveniles: See responses to increased turbidity exposure described under Water Quality Modification. <u>Adults</u> : Potential reduction of suitable spawning habitat, leading to decreased spawning productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival. May affect growth and fitness at larv and juvenile life-history stages. May affect adult spawning fitne and productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Leaf litter and other detritus may influence microclimate conditions in spawning substrates. Reduction in leaf litter may cause reduced incubation success. Larvae, juveniles, and adults: Dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubatine ggs. Potential effects resulting from this impact mechanism on remaining life-history stages arounknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Sensitivity to stressor exposure currently a data gap for these species; the potential effects resulting from this impact mechanism are unknown.

Table A-16 (continued).

			Ex	posure					
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs:Groundwater inflow demonstrably affects substrate temperatures, creating favorable conditions for egg incubation.Larvae and juveniles:Dependence of larval and juvenile forage fish on surface water and groundwater exchange in nearshore habitats is currently a data gap; the potential for exposure to these stressors is unknown.Adults:Altered groundwater inflow may affect spawning habitat suitability, leading to decreased spawning success.	Avoid disturbance of vegetation along shoreline.	May affect egg survival and adult spawning productivity. Potential effects resulting from this impact mechanism on larvae and juveniles are unknown.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u> : Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect larvae development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand L

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawn	ning Substrate Aug	mentation							
	Not applicable								
In-Cha	annel/Off-Channel	Habitat Creation/Modific	ation						
	Not applicable								
Ripari	an Planting/Restor	ation Enhancement							
	Construction and Maintenance Activities								
	Marine	1		1				1	1
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs	Eggs: Surf smelt and sand lance incubation success is demonstrably affected by microclimate conditions in the nearshore environment that are influenced by riparian vegetation. Alteration of riparian vegetation has been demonstrated to reduce egg survival and incubation success.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect egg survival, decreasing population productivity.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
	Aquatic Vegetation Modification								
	Marine	1		1					
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.

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Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

ıb-			Ex	posure		.			
tivity /pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs	Eggs: Surf smelt and sand lance incubation success is demonstrably affected by microclimate conditions in the nearshore environment that are influenced by riparian vegetation. Alteration of riparian vegetation has been demonstrated to reduce egg survival and incubation success.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect egg survival, decreasing population productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u> : Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic erosion. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity larval, juvenile, and adult life-history stages.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

	-		Ex	posure	·	_			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
an	d Creation Restor	ation/Enhancement							
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predat risk.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stresso under Water Quality Modific

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: These life-history stages will be difficult to capture and relocate effectively. <u>Adults</u> : Capture, handling, and relocation is likely to cause mortality, or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Capture/removal of larvae and juveniles is impractical, meaning that these activities are likely to affect larval and juvenile survival. Capture and removal of adults is likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause injury and mortality of larvae, juveniles, and adults. Effects are less likely to occur if activities are conducted outside of spawning season.
		Benthic disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Potential decreased larval foraging success due to turbidity exposure and substrate disturbance, leading to decreased growth and fitness. <u>Adults and juveniles</u> : Stress caused by avoidance behavior; decreased foraging success due to increased turbidity levels.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect larval productivity. May affect juvenile and adult survival and productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Surf smelt and sand lance dependence on benthic invertebrates for forage is likely limited but is currently a data gap. Therefore, the potential effects of stressor exposure are unknown.	Limit area of dewatering to the greatest extent practicable.	Potential effects resulting from this impact mechanism are unknown.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u> : Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.

Table A-16 (continued).

Table A-16 (continued).

r			Ex	posure			-		
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit in-water heavy machinery use.	May affect survival, growth, and fitness of juveniles and adults.
hÌ	Nourishment/Cont	couring							
	Construction and Maintenance Activities								
	Marine								
,	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of eggs and larvae	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles;	Eggs and Larvae: Direct mortality from smothering Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage. Reduc reproductive success from destru of eggs.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of eggs and larvae	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles;	Eggs and Larvae: Direct mortality from smothering Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage. Reduc reproductive success from destru of eggs.
	Aquatic Vegetation Modification					•			
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Eggs; Larvae;	Eggs: Alteration or reduction of submerged aquatic vegetation component of beach wrack may affect microclimate	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of	May affect growth and fitness at larval, juvenile, and adult life-his stages.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered cover and habitat	Reduced cover				Juveniles; Adults	conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). <u>All life-history stages</u> : Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	prod
	Water Quality Modification							
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u> : Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensu mini: to ch short back pract turbi
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr water

Table A-16 (continued).HPA

Minimization Measures oductive, vegetated aquatic habitat.	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic shoreline instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
fuel and service machinery in a ntrolled environment away from the tter body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-16 (continued).

)- vity			Ex	posure		_		Resulting Effects of the	
vity be	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
eef C	reation/Restoratio	n/Enhancement							
	Construction and Maintenance Activities								
Γ	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-histo stages, depending on project-specif noise intensity and receptor exposu Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	J <mark>uvenil</mark> es; Adults	<u>Adults and juveniles</u> : May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predatio risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

)-			Exposure									
vity De	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Hydraulic and Geomorphic Modification											
	Marine											
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival at the larval and juvenile life-history stages. May aff juvenile and adult growth and fitnes Decreased fitness may affect spawn productivity.			
	Altered nearshore circulation patterns Altered current velocities		seasonally variable effects depending on site-specific geography and bathymetry, and	Permanent	Seasonal		or more of these parameters can fundamentally alter marine littoral habitats. Egg incubation success may be affected by alteration in wave energy patterns and groundwater inputs. Alteration of current velocities and circulation patterns may cause	patterns, and wave energy and current patterns.				
			Permanent	Intermittent		transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment.						
-	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		Therefore, alteration of these parameters may affect foraging opportunities for at larval and juvenile life-history stages, leading to decreased adult fitness, decreased survival, and decreased					
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		spawning productivity.					
	Ecosystem Fragmentation											
ŀ	Marine	1	1	1	1		Τ	1	1			
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.			

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification		-					-	-
	Marine		_						
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Alteration or reduction of submerged aquatic vegetation may affect microclimate conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). <u>All life-history stages</u> : Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u> : Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of larvae, juveniles, and adults.
	cass and Other Aqu on/Restoration/Enl								
	Construction and Maintenance Activities								
1	Marine								

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-			Exj	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Adhere to system-specific in-water work windows.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-17. HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

b-			Ex	posure				
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
eaver	Dam Removal			• •				
	Not applicable							
acem	nstruction impacts	moval (for placement s apply)						
	Construction and Maintenance Activities							
	Marine							
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills) Elevated noise, visual, physical disturbance	During project construction activities During project construction and maintenance activities	Temporary to short- term Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults Eggs; Larvae; Juveniles; Adults	 <u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane (from exposure to high intensity noise such as pile driving). Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral 	Refue contro water work Avoid impac NOA habita drivir Use d reduc confin Encoo and w Limit mach

Minimization Measures

Resulting Effects of the Submechanism

efuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the project area.

void pile-driving noise in excess of pact thresholds established by DAA Fisheries and USFWS in bitats used by species. Limit pile iving to in-water work windows. se double-confined bubble curtain to duce sound pressure, or work within nfined or dewatered work areas. acourage use of vibratory hammers d wooden pilings where practicable. mit in-water use of heavy achinery. May affect survival, growth, and fitness of juveniles and adults.

May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

ıb-			Exj	posure	1				
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area	Fish removal releastion and	During project	Short tam	Interennuel to		Larvas and invanilas: These life history	Use protocole optiblished by NOA A	Conture/computed of larges and
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: These life-history stages will be difficult to capture and relocate effectively. <u>Adults</u> : Capture, handling, and relocation is likely to cause mortality, or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Capture/removal of larvae and juveniles is impractical, meaning that these activities are likely to affect larval and juvenile survival. Capture and removal of adults is likely to affe survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause injury and mortality of larvae, juveniles, and adults. Effects are less likely to occur if activities are conducted outside of spawning season
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All life-history stages:</u> Herring dependence on benthic invertebrates for forage is likely limited but is currently a data gap. Therefore, the potential effects of stressor exposure are unknown.	Limit area of dewatering to the greatest extent practicable.	Potential effects resulting from this impact mechanism are unknown.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect egg and larval survival and larval fitness. Decreased larval fitness may affect survival and productivity during juvenile and adult life-history phases in offshore and open ocean environments, and may affect spawning productivity. Loss or alteration of suitable spawning habitat may affect spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		or more of these parameters can fundamentally alter marine littoral habitats. Alteration in the aerial extent and composition of the submerged aquatic vegetation community resulting from these mechanisms may reduce available spawning habitat, leading to		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		reduced spawning productivity. Egg incubation success may be affected by alteration in wave energy patterns. Alteration of current velocities and		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		circulation of current verocities and circulation patterns may cause ransportation of planktonic larvae to infavorable habitats for growth and development. Alteration of nearshore nabitat productivity may also have concomitant effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities at the uvenile life-history stage, over time eading to decreased adult fitness,		
							decreased survival, and decreased spawning productivity.		
	Ecosystem Fragmentation								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: LWD removal in the marine environment can fragment nearshore rearing habitat, potentially forcing planktonic herring away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion. <u>Adults</u> : LWD removal and the resultant geomorphic effects on the middle and lower intertidal zone may eliminate or decrease the suitability of spawning habitat, potentially limiting the spawning productivity of affected populations.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval and juvenile survival, growth, and fitness. May affect adult survival, fitness, and spawning productivity.

Exposure **Mechanism of Impact** Stressor When Duration Frequency Life-history Form **Response to Stressor** Reduced recruitment of terrestrially See responses to altered habitat complexity Altered cover and habitat Year-round Permanent Continuous Juveniles under Riparian Vegetation Modification. derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs **Aquatic Vegetation** Modification Marine Altered autochthonous All life-history stages: Altered habitat Reduced food web productivity Year-round (most Permanent Continuous Eggs; complexity is likely to affect food web production pronounced in spring Larvae; dynamics and available foraging and summer when Juveniles; opportunities, potentially resulting in vegetation growth is Adults decreased growth and fitness. most extensive) Adults: Reductions in available submerged aquatic vegetation or alteration of submerged aquatic vegetation community composition may limit spawning productivity. Altered dissolved oxygen levels due to Year-round (most Permanent Seasonal Juveniles <u>Juveniles</u>: See related stressor responses reduced photosynthesis pronounced in spring under Water Quality Modification. and summer when vegetation growth is most extensive) Reduced food web productivity, All life-history stages: Altered habitat Altered habitat complexity Year-round Short-term to Continuous Eggs; complexity is likely to affect food web reduced foraging opportunity, permanent Larvae; dynamics and available foraging reduction in available cover (dependent on nature

of activity)

HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring. Table A-17 (continued).

Sub-

Туре

activity

Juveniles;

Adults

opportunities, potentially resulting in

decreased growth and fitness. Adults: Reductions in available submerged aquatic vegetation or alteration of submerged aquatic vegetation community composition may

limit spawning productivity.

Minimization Measures	Resulting Effects of the Submechanism
Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.
	See effects for related stressors under Water Quality Modification.
	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Riparian Vegetation Modification	-	-	-	•	-		
	Marine		-					- -
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs	Eggs: The influence of marine riparian shading on herring incubation is likely limited due to the typical elevation of herring spawn in the upper subtidal zone. However, the effects of this stressor are currently a data gap.	Avoid riparia approj the gro
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: See responses to increased turbidity exposure described under Water Quality Modification. <u>Adults</u> : Potential reduction of suitable spawning habitat, leading to decreased spawning productivity.	Avoid riparia approj the gro
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	J <mark>uvenil</mark> es; Adults	<u>Juveniles and adults</u> : Dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid riparia approp the gro
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Encou perma habita
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Adults	Eggs and larvae: Herring egg and larval development is demonstrably affected by surface water salinities beyond tolerance thresholds. Alteration of salinity characteristics may limit egg survival or cause larval abnormalities limiting to survival, growth, and fitness. <u>Adults</u> : The influence of surface water and groundwater exchange on spawning habitat suitability is currently a data gap. However, alteration of this habitat parameter that affect submerged aquatic vegetation may decrease availability and/or suitability of spawning habitat.	Avoid shorel

Minimization Measures	Resulting Effects of the Submechanism
Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival. May affect productivity at larval and juvenile life-history stages. May affect adult spawning productivity.
Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism on remaining life-history stages are unknown.
Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect larval, juvenile, and adult productivity. May affect adult spawning productivity.
Avoid disturbance of vegetation along shoreline.	May affect egg and larval survival and productivity. May affect adult spawning productivity.

Sub-			Ex	posure	1	1		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification	-	-	-	-		-	
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u> : Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensu minii to ch short back pract proto turbi
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensu drast comp
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensu drast com

Spawning Substrate Augmentation

Not applicable

In-Channel/Off-Channel Habitat Creation/Modification

Not applicable

Riparian Planting/Restoration Enhancement

8							
Construction and Maintenance Activities							
Marine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs	Eggs: The influence of marine riparian shading on herring incubation is likely limited due to the typical elevation of herring spawn in the upper subtidal zone. However, the effects of this stressor are currently a data gap.	Minin specie assure specie

Minimization Measures	Resulting Effects of the Submechanism
Ensure project design avoids and/or ninimizes habitat alterations leading o chronic bank instability. Avoid short-term turbidity effects above packground levels to greatest extent practicable. Adhere to established protocols for managing sediment and urbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.
Ensure project design does not frastically reduce hydraulic complexity or impact riparian buffers.	May affect larvae development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.
Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	Potential effects resulting from this impact mechanism are unknown.

Sub-			Ex	posure	<u>.</u>			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Minin specie erosic after
	Aquatic Vegetation Modification							
	Marine	1	1	T			1	
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Desig canop conti

Minimization Measures	Resulting Effects of the Submechanism
nimize disturbance during invasive eccies removal. Use appropriate osion control BMPs both during and er construction.	See effects for related stressors under Water Quality Modification.
sign riparian patches with variable hopy coverage so that sunlight will ntinue to reach the water surface.	May affect juvenile growth and fitness, data gap.

Exposure Mechanism of Impact Stressor When Duration Life-history Form Frequency **Response to Stressor Riparian Vegetation** Modification Decreased productivity (locally due to increased shading) De Altered Shading and solar Year-round (most Permanent Continuous Juveniles <u>Juveniles</u>: Reduced foraging opportunities pronounced in spring due to decreased food web productivity and var and summer when decreased growth and fitness. sur vegetation growth is wa most extensive) Water Quality

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Modification							
Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs	Eggs: The influence of marine riparian shading on herring incubation is likely limited due to the typical elevation of herring spawn in the upper subtidal zone. However, the effects of this stressor are currently a data gap.	Minir specie assure specie
Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u> : Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Minir specie erosic after o

Sub-

Туре

activity

Marine

input

Minimization Measures	Resulting Effects of the Submechanism
esign riparian patches with riable canopy coverage so that nlight will continue to reach the ater surface.	May affect juvenile growth and fitness, data gap.
inimize disturbance during invasive ecies removal. Use measures to sure rapid establishment of planted ecies.	Potential effects resulting from this impact mechanism are unknown.
inimize disturbance during invasive ecies removal. Use appropriate osion control BMPs both during and er construction.	May affect survival and productivity at egg, larval, juvenile, and adult life- history stages.

			Ex	posure										
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism					
tlan	nd Creation Restor	ation/Enhancement												
	Construction and Maintenance Activities													
	Marine													
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.					
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect growth, fitness, and survival due to avoidance behavior, decreased foraging success, and increased predation risk.					
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressor under Water Quality Modifica					

)-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	Eggs: Extended dewatering may lead to egg desiccation or thermal exposure, causing mortality, or larval abnormalities limiting to survival. Larvae and juveniles: Dewatering is likely to lead to mortality, as larval and juvenile herring will be difficult to capture and relocate effectively. <u>Adults</u> : Capture, handling, and relocation are likely to cause mortality, or injury and stress, leading to mortality or decreased spawning fitness.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Dewatering and fish removal in marine habitats is an unlikely requirement for LWD projects. However, in the event that such activities are required, adverse effects on exposed life-history stages should be expected. Capture and removal of larvae an juveniles is impractical, meaning that these activities are likely to affect larval and juvenile surviva Capture and removal of adults is likely to affect survival and spawning productivity.	
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u> : Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause injury and mortality o larvae, juveniles, and adults. Effects are less likely to occur if activities are conducted outside o spawning season.
	Benthic disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	Larvae: Potential decreased larval foraging success due to turbidity exposure and substrate disturbance, leading to decreased growth and fitness. <u>Adults and juveniles</u> : Stress caused by avoidance behavior; decreased foraging success due to increased turbidity levels. <u>Adults</u> : Decreased availability of spawning substrate due to sedimentation effects on submerged aquatic vegetation. <u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	The likely stressor is increased suspended solids. May affect larval growth and survival. May affect juvenile and adult survival May affect adult spawning productivity.	
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Herring dependence on benthic invertebrates for forage is likely limited but is currently a data gap. Therefore, the potential effects of stressor exposure are unknown.	Limit area of dewatering to the greatest extent practicable.	Potential effects resulting from this impact mechanism are unknown.

			Ex	posure					
у	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at egg, larval, juvenile, and adult life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit in-water heavy machinery use.	May affect survival, growth, and fitness of juveniles and adults.
h	Nourishment/Cont	ouring							
	Construction and Maintenance Activities	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~							
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of eggs and larvae	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles;	Eggs and Larvae: Direct mortality from smothering Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage. Reduce reproductive success from destruc of eggs.

Marine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate work
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of eggs and larvae	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles;	Eggs and Larvae: Direct mortality from smothering Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoi produ com

ity			Ex	posure	ŕ	ŕ	_		
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of eggs and larvae	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles;	Eggs and Larvae: Direct mortality from smothering Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage. Reduced reproductive success from destruction of eggs.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Eggs; Larvae; Juveniles;	All life-history stages: Reductions in available submerged aquatic vegetation is likely to affect food web dynamics and available foraging opportunities,	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect productivity at larval juvenile, and adult life-history stages.
	Altered cover and habitat	Reduced cover				Adults	available for aging opportunities,potentially resulting in decreased growthand fitness. <u>Adults</u> : Reductions in availablesubmerged aquatic vegetation oralteration of submerged aquaticvegetation community composition maylimit spawning productivity.		
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivit egg, larval, juvenile, and adult life- history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Reef (Creation/Restoratio	n/Enhancement						
	Construction and Maintenance Activities							
	Marine							
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoi perio prese
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	J <mark>uvenile</mark> s; Adults	<u>Adults and juveniles</u> : May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoi noise equip techr
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoi prod com

Minimization Measures	Resulting Effects of the Submechanism
oid construction activities during riods when individuals may be essent, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
oid/minimize cavitation to limit ise intensity. Promote use of vessels uipped with antinoise/antivibration hnology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
roid project site which are oductive and have a healthy benthic mmunity.	May affect growth and fitness at juvenile life-history stage.

ity			Exj	oosure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Τ	Hydraulic and Geomorphic Modification		-	-	-	-			-
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect egg and larval surviva larval fitness. Decreased larval fi may affect survival and productiv during juvenile and adult life-histo phases in offshore and open ocean environments, and may affect
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		or more of these parameters can fundamentally alter marine littoral habitats. Alteration in the aerial extent and composition of the submerged aquatic vegetation community resulting from these mechanisms may reduce available spawning habitat, leading to	patterns, and wave energy and current patterns.	spawning productivity. Loss or alteration of suitable spawning hab may affect spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		reduced spawning productivity. Egg incubation success may be affected by alteration in wave energy patterns. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment.		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		Therefore, alteration of these parameters may affect foraging opportunities at the juvenile life-history stage, over time leading to decreased adult fitness, decreased survival, and decreased spawning productivity.		
ļ	Ecosystem Fragmentation								
-	Marine		1	1				1	r
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, grow and fitness.

-			Ex	posure	1	-			
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification			-					
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Alteration or reduction of submerged aquatic vegetation may affect microclimate conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). <u>All life-history stages</u> : Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness at eg larval, juvenile, and adult life-histo stages.
	Water Quality Modification	-							
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u> : Same effects as above, as well as increased stress and decreased for since the stress and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at egg, larval, juvenile, and adult life-history stages.
	Altered pollutant loading	Leaching of toxic substances	Year-round	Intermediate-term	Continuous with	Eggs;	decreased foraging opportunity due to avoidance behavior. <u>All life-history stages</u> : Physiological	Use non-toxic reef material.	May affect survival and
	Antered pointaint toading	(depending on composition of reef material)			seasonal pulses (dependent on current velocity)	Lggs, Larvae; Juveniles; Adults	responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.		productivity of larvae, juveniles and adults.
	ass and Other Aqu on/Restoration/Enh								
	Construction and Maintenance Activities								

struction and ntenance Activities	
ine	

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Adhere to system-specific in-water work windows.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

			EX	posure			-		Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
r I	Dam Removal								
ľ	Not applicable								
e W	Voody Debris								
		moval (for placement							
:0n	struction impacts	s apply)							
	Construction and Maintenance Activities								
	Marine								
F	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, an fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>Juveniles and adults</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Fatal injury or permanent auditory tissue damage limiting to survival. 1) Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey. 2) Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Activity may cause direct mortality or otherwise affect survival, growth, and fitness life-history stages, depending project-specific noise intensi receptor exposure.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors Water Quality Modification.

			Ex	posure					
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine	·	·	·	<u>.</u>		·	·	·
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival, growth, and fitness at larval and juvenile life history stages.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval lingcod settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing	Y Y	
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure		
-	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.		
	Ecosystem Fragmentation		anchor trenchingj)						
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: LWD removal in the marine environment can fragment nearshore rearing habitat, potentially affecting settlement of larval lingcod. LWD removal May decrease nearshore habitat suitability for juvenile lingcod by removing interstitial cover; however, the resulting potential effects on lingcod populations are a data gap. <u>Adults</u> : LWD removal in the marine environment may remove three- dimensional habitat suitable for adult lingcod in the nearshore environment, encouraging occupation. The resulting potential effects on lingcod populations	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Potential effects on juvenile an adult lingcod are a data gap.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Enco perm habit
	Aquatic Vegetation Modification							
	Marine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Cons distu durin
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	
							<u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	



Minimization Measures	Resulting Effects of the Submechanism
courage project designs that limit rmanent alteration of high-quality bitat features.	May affect juvenile survival.
nstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	May affect juvenile growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival. May affect adult growth and fitness.

ıb-			Ex	posure	1			
tivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Riparian Vegetation Modification	-	-	-	-	-		
	Marine							
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid ripari appro the gr
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid ripari appro the gr
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Lingcod dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juveniles are known to use shallow vegetated habitats and pocket estuaries which contain food sources that depend on marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid ripari appro the gr
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Enco perm habit

Minimization Measures	Resulting Effects of the Submechanism
Avoid/minimize disturbance of iparian vegetation. Maintain system- appropriate riparian buffer widths to he greatest extent possible.	May affect juvenile survival and productivity. Currently a data gap.
Avoid/minimize disturbance of iparian vegetation. Maintain system- appropriate riparian buffer widths to he greatest extent possible.	May affect juvenile survival. Currently a data gap.
Avoid/minimize disturbance of iparian vegetation. Maintain system- appropriate riparian buffer widths to he greatest extent possible.	May affect juvenile growth and fitness
Encourage project designs that limit bermanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.

-		Exposure										
vity e	Mechanism of Impact	Stressor	When	When Duration Frequency		Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile lingcod are known to selectively settle and rear in areas with reduced salinities; therefore, groundwater inflow may provide increased habitat suitability. Reduction in suitable habitat area may affect survival, growth, and fitness.	Avoid disturbance of vegetation along shoreline.	May affect survival, growth, and fitness of juveniles.			
	Water Quality Modification											
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.			
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.			
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. (Egg exposure may occur in rare circumstances if nests are located close to shore.) Juveniles and adults: Avoidance behavior or asphyxiation during acute events.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of incubating eggs and larvae. May affect juvenile and adult survival. May cause temporary avoidance behavior, potentially leading to decreased growth and fitness.			

		-					
		Ex	posure				
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
ing Substrate Aug	mentation						
Not applicable							
nnel/Off-Channel	Habitat Creation/Modific	ation					
Not applicable							
an Planting/Restor	ation Enhancement						
Construction and Maintenance Activities							
Marine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Mi spo ass spo
	Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Mi spe ero afte
Aquatic Vegetation Modification							
	ng Substrate Aug Not applicable mel/Off-Channel Not applicable n Planting/Restor Construction and Maintenance Activities Marine Bank, Channel, Shoreline Disturbance	ng Substrate Augmentation Not applicable nmel/Off-Channel Habitat Creation/Modific Not applicable m Planting/Restoration Enhancement Construction and Maintenance Activities Marine Bank, Channel, Shoreline Disturbance Disturbance Increased summer temperatures, decreased winter temperatures) Increased suspended solids – due to removal of invasive riparian species Increased suspended solids – due to removal of invasive riparian species Increased suspended solids – due to removal of invasive riparian species	Mechanism of Impact Stressor When ng Substrate Augmentation Not applicable Incl/Off-Channel Habitat Creation/Modification Not applicable Incl/Off-Channel Habitat Creation/Modification Incl/Off-Channel Habitat Creation/Modification Not applicable Incleased Summer Creation Fundancement Incleased Summer Creation Species (L.c., increased summer temperatures) Year-round (pronounced in winter/summer during solar radiation and ambient temperatures) Bank, Channel, Shoreline Expansion of thermal regime - due to removal of invasive riparian species (L.c., increased summer temperatures) Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes) Increased suspended solids - due to removal of invasive riparian species Year-round (with specific stressors prominent during high flow conditions) Increased suspended solids - due to removal of invasive riparian species Year-round (with specific stressors prominent during high flow conditions)	ng Substrate Augmentation Not applicable nnel/Off-Channel Habitat Creation/Modification Not applicable n Planting/Restoration Enhancement Construction and Maintemance Activities Marine Bank, Channel, Shoreline Disturbance Disturbance (i.e., increased summer temperatures, decreased winter temperatures) Increased suspended solids - due to removal of invasive riparian species Increased suspended solids - due to removal of invasive riparian species Vear-round (with specific stressors prominent during high flow conditions) Increased suspended solids - due to removal of invasive riparian species Vear-round (with specific stressors prominent during high flow conditions) Augutic Vegetation	Mechanism of Impact Stressor When Duration Frequency ng Substrate Augmentation Not applicable Impact/Off-Channel Habitat Creation//Iodification Impact Augmentation Impact Augmentation <td>Mechanism of Impact Stressor When Duration Frequency Life-history form In Substrate Augmentation Not applicable Not applicable</td> <td>Nethanism of Inquit Stressor When Duration Preparency Life-bisiony from Response to Stressor ng Substrate Augurentation </td>	Mechanism of Impact Stressor When Duration Frequency Life-history form In Substrate Augmentation Not applicable Not applicable	Nethanism of Inquit Stressor When Duration Preparency Life-bisiony from Response to Stressor ng Substrate Augurentation

Minimization Measures	Resulting Effects of the Submechanism
Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.

Sub-			Exposure						
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.
	Riparian Vegetation Modification								
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.

		Ex	posure					
ty Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
tland Creation Rest	oration/Enhancement							
Construction and Maintenance Activities								
Marine								
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect growth, fitness, and survival due to avoidance behavior, decreased foraging success, and increased predatio risk.
Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors un Water Quality Modification.

Sub-			E	xposure		1		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensu mini to ch shor back prace proto turbi
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate mach

Beach Nourishment/Contouring

Construction and Maintenance Activities							
Marine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu contr wate work
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of juveniles	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles;	<u>Juveniles</u> : Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid burial. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.	Avoi produ com

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.
fuel and service machinery in a ntrolled environment away from the ter body. Limit in-water heavy ichinery use.	May affect survival, growth, and fitness of juveniles and adults.
fuel and service machinery in a ntrolled environment away from the ter body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of juveniles and adults.
roid project site which are oductive and have a healthy benthic mmunity.	May affect growth and fitness at juvenile life-history stage.

			Exposure						
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of juveniles	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles;	<u>Juveniles</u> : Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid burial. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
Γ	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. Maffect adult growth and fitness.
	Altered cover and habitat	Reduced cover					decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness)	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, an fitness at larval, juvenile, and ad life-history stages.

ub-			Ex	posure		_			
tivity 7pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.
eef (Creation/Restoratio	n/Enhancement							
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently data gap.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. <u>All exposed life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality or injury to juveniles. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.

)-			Ex	posure					
v ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival, growth, and fitness at larval and juvenile lift history stages.
	Altered nearshore circulation patterns Altered current velocities		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval lingcod settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing	patterns, and wave energy and current patterns.	
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		decreased growth, decreased fitness, and direct mortality.		
	Ecosystem Fragmentation								
	Marine	1			-		1		1
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, grow and fitness.

		E	xposure	1	1	-		Resulting Effects of the
Mechanism of Im	act Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Aquatic Vegetation Modification								
Marine Altered cover and hal	tat Decreased refuge and forage habitat	Year-round	Short-term to	Continuous	Juveniles;	Juveniles: Decreased refuge habitat	Avoid/minimize disturbance of aquatic	May affect juvenile survival. Ma
			permanent (dependent on nature of activity)		Adults	availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	vegetation during project construction.	affect adult growth and fitness.
Water Quality Modification								
Altered suspended so		Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval, juvenile, and adu life-history stages.
Altered pollutant load	ng Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of larvae, juveniles, and adults.

Sub-			Ex	xposure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Adhere to system-specific in-water work windows.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
er]	Dam Removal								
	Not applicable								
e V	Voody Debris	moval (for placement							
eme	ent/Movement/Re	moval (for placement							
cor	nstruction impact	s apply)							
	Construction and Maintenance Activities								
	Marine					-			
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles	 <u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Barotraumas causing fatal injury or permanent auditory tissue damage in larvae, juveniles, and adults limiting to survival. 1) Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey. 2) Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decrease growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Activity may cause direct mortality or otherwise affect survival, growth, and fitness ar all life-history stages, dependir on project-specific noise intens and receptor exposure.

Sub-			Ex	posure	1	r		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoi ripari shore prope
	Hydraulic and Geomorphic Modification							
	Marine		1	1				
l	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Caref desig impa- proje desig sedin
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval settlement in nearshore areas favorable for rearing, as well as the overall suitability of juvenile rearing habitat. This may occur through	patter patter
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure	
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of arian vegetation. Limit bank, oreline and benthic disturbance. Use oper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and current tterns.	May affect survival, growth, and fitness at larval and juvenile life- history stages.

			E	xposure					
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles	<u>Larvae and juveniles</u> : LWD removal in the marine environment can fragment nearshore rearing habitat, potentially affecting settlement of larval cod, pollock, and hake.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, growt and fitness.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
		1	1	-	-			1	
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Reduced food web productivity Altered dissolved oxygen levels due to reduced photosynthesis	pronounced in spring and summer when vegetation growth is	Permanent Permanent	Continuous	Juveniles	opportunities due to decreased food web productivity; decreased growth and	disturbance of aquatic vegetation	

		Exj	posure		. <u>.</u>			
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Riparian Vegetation Modification	-	-	-	-	-		-	
Marine								
Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity. Currently a data ga
Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pacific cod, hake and walleye pollock dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juvenile Pacific cod, hake, and walleye pollock are known to use shallow vegetated habitats that could have marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Pacific cod, hake, and walleye pollock dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of action are unknown as receptor sensitivity to this stresso is currently a data gap.

Sub-Exposure activity **Mechanism of Impact** Stressor When Duration Frequency Life-history Form **Response to Stressor** Туре Water Quality Modification Altered suspended solids Increased suspended solids Dependent on Temporary to long-Continuous to Larvae: Larvae: Increased suspended solids in Ens microlayer habitat may lead to direct contributing term (dependent on interannual-decadal miı Juveniles mechanism of impact contributing (dependent on mortality and decreased larval survival. to mechanism of contributing sho Juveniles: Responses vary depending on bac impact) mechanism of stressor magnitude. Unavoidable impact) extreme turbidity may cause physical pra injury and/or physiological effects (e.g., pro gill trauma, altered osmoregulation, turl blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. Ens Altered pollutant loading Increased pollutant loading Dependent on Eggs; All life-history stages: Physiological Temporary to short-Intermittent to term (dependent on dra contributing responses to exposure at toxic levels, permanent Larvae; causing mortality or injury leading to mechanism of impact contributing (dependent on cor Juveniles reduced fitness. Bioaccumulation of mechanism of contributing contaminants at subacute levels, resulting impact) mechanism of in chronic physiological effects leading to impact) reduced fitness and/or mortality. Larvae: Mortality due to asphyxiation in Ens Altered dissolved oxygen Decreased dissolved oxygen (due to Dependent on Temporary to short-Intermittent to Larvae: acute low microlayer dissolved oxygen eutrophication caused by elevated permanent dra contributing term to seasonal Juveniles mechanism of impact (dependent on nutrient export from dewatered (dependent on events. cor floodplains) contributing contributing Juveniles: Physiological responses to mechanism of mechanism of exposure at toxic levels causing mortality impact) impact) or injury leading to reduced fitness. Avoidance behavior leading to increased competition, predation exposure, and decreased foraging opportunity. **Spawning Substrate Augmentation** Not applicable **In-Channel/Off-Channel Habitat Creation/Modification** Not applicable

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Riparian Planting/Restoration Enhancement

Construction and Maintenance Activities

Marine

Minimization Measures	Resulting Effects of the Submechanism
nsure project design avoids and/or inimizes habitat alterations leading chronic bank instability. Avoid out-term turbidity effects above ackground levels to greatest extent acticable. Adhere to established otocols for managing sediment and rbidity.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
nsure project design does not astically reduce hydraulic omplexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.
nsure project design does not astically reduce hydraulic omplexity or impact riparian buffers.	May cause direct mortality of larvae and juveniles. May affect juvenile survival, growth, and fitness.

			Exposure						
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles;	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
	Aquatic Vegetation Modification								
-	Marine		/			T '1			
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.

Sub-			Ex	posure			_		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification							-	
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness at larval and juvenile life- history stages.

		Exposure						
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
and Creation Restor	ation/Enhancement							
Construction and Maintenance Activities								
Marine								
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, ar fitness due to avoidance behavi decreased foraging success, and increased predation risk.
Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors un Water Quality Modification.

b-			Ex	posure	T	-			
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit in-water heavy machinery use.	May affect survival, growth, and fitness of juveniles and adults.
each	Nourishment/Cont Construction and Maintenance Activities	touring							
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of juveniles	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Juveniles</u> : Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. <u>All exposed life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of juveniles. May affect juvenile survival, growth, and fitness. See effects for related stressors under Water Quality Modification.

Marine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu cont wate worl
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of juveniles	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles:Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment.Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.All exposed life-history stages:See responses described for related stressors under Water Quality Modification.	Avo prod com

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

			Ex	posure							
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Hydraulic and Geomorphic Modification										
	Marine										
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of juveniles	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles;	<u>Juveniles</u> : Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid burial. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.		
	Aquatic Vegetation Modification										
	Marine										
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival growth and fitness.		
	Altered cover and habitat	Reduced cover					decreased survival, growth, and fitness.	productive, vegetated aquate national.			
	Water Quality Modification										
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, a fitness at larval and juvenile l history stages.		
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.		

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-			Ex	posure				Τ
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Reef C	Creation/Restoratio	n/Enhancement						
	Construction and Maintenance Activities							
	Marine							
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avperpre
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Av no equ tec
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Juveniles</u> : Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. <u>All exposed life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Av pro co

Minimization Measures	Resulting Effects of the Submechanism
void construction activities during eriods when individuals may be resent, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
void/minimize cavitation to limit bise intensity. Promote use of vessels puipped with antinoise/antivibration chnology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
void project site which are roductive and have a healthy benthic ommunity.	May cause direct mortality of juveniles. May affect juvenile survival, growth, and fitness. See effects for related stressors under Water Quality Modification.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification		-		-	-	-		-
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival, growth, and fitness at larval and juvenile life- history stages.
	Altered nearshore circulation patterns	ation patterns ed current velocities	Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal			patterns, and wave energy and current patterns.	
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth decreased fitness and		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		decreased growth, decreased fitness, and direct mortality.		
	Ecosystem Fragmentation			1					
	Marine					-			
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

			E	kposure	1			Resulting Effects of the	
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth a fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, fitness at larval and juvenile history stages.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of larvae, juven and adults.
tio	uss and Other Aqu n/Restoration/Enh Construction and Maintenance Activities	atic Vegetation nancement							
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Adhere to system-specific in-water work windows.	May affect survival and productivity due to avoidanc behavior, decreased foraging success, and increased preda risk. Actual effects are unkn as stressor sensitivity is curre data gap.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	transplantation projects are not likely to cause pulses of suspended sediment sufficient to	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

			Ex	posure	1		4		Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
er I	Dam Removal								
Ν	Not applicable								
e W	oody Debris								
		moval (for placement							
con	struction impacts	s apply)							
	Construction and Aaintenance Activities								
E	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Larvae; Juveniles	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, a fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>Juveniles and adults</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Fatal injury or permanent auditory tissue damage limiting to survival. 1) Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. 2) Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Activity may cause direct mortality or injury affecting juvenile and adult survival, depending on project-specif noise intensity and receptor exposure.

Table A-20. HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-			Ex	posure			-	
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid ripari shore prope
	Hydraulic and Geomorphic Modification							
	Marine							
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Caref desig impac proje desig sedin
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval rockfish settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat. This may occur through a	patte:
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure	
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	

Table A-20 (continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Minimization Measures	Resulting Effects of the Submechanism
roid/minimize disturbance of arian vegetation. Limit bank, oreline and benthic disturbance. Use oper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and current tterns.	May affect survival, growth, and fitness at larval and juvenile life- history stages.

Table A-20 (continued).HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

b-			Ex	posure					
vity De	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation							-	
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	y, as well as reduced food plexity, habitat availability, pility	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: LWD removal in the marine environment can fragment nearshore rearing habitat, potentially affecting settlement of larval rockfish.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Potential effects on juvenile and adult rockfish are a data gap.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased refuge habitat availability. Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and fitness.

ıb-			Ex	posure					
tivity /pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification	-				-	-	-	-
	Marine		-		-				
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Rockfish dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juvenile rockfish are known to use shallow vegetated habitats and pocket estuaries which contain food sources that depend on marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Rockfish dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism ar unknown.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-			Ex	posure					
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification	-	-	-	-	-	-	-	-
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. Juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Avoidance behavior leading to increased competition, predation exposure, and decreased foraging opportunity.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May cause direct mortality of larvae and juveniles. May affect juvenile survival, growth, and fitness.
pawn	ing Substrate Aug	nentation							
	Not applicable								
n-Cha	nnel/Off-Channel	Habitat Creation/Modific	ation						
	Not applicable								
Riparia	an Planting/Restor	ation Enhancement							
	Construction and Maintenance Activities								
	Marine								

Table A-20 (continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Table A-20 (continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-			Ex	posure		_			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	<u>Juveniles</u> : Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles;	All life-history stages: See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
	Aquatic Vegetation Modification								
	Marine	1			1	I	I	Γ	
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased refuge habitat availability. Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile survival. May affect adult growth and fitness.

)-			Ex	posure					
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness at larval and juvenile life- history stages.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Table A-20 (continued).HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

		Ex	posure					
7 Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
land Creation Restor	ration/Enhancement							
Construction and Maintenance Activities								
Marine								
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, an fitness due to avoidance behavi- decreased foraging success, and increased predation risk.
Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors un Water Quality Modification.

Table A-20 (continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

			Ex	posure		·	_		
7	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, a fitness at larval and juvenile li history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit in-water heavy machinery work.	May affect survival, growth, and fitness of juveniles and adults.
	Construction and Maintenance Activities								
		_							
	Maintenance Activities	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Construction and Maintenance Activities							
Marine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ref con wat wo
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of juveniles	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles:Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment.uveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.All exposed life-history stages:See responses described for related stressors under Water Quality Modification.	Ave pro con

-			Ex	posure					
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of juveniles	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles;	<u>Juveniles</u> : Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid burial. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival growth and fitness.
	Altered cover and habitat	Reduced cover					decreased survival, growth, and fitness.	productive, vegetated aquate naoraa.	
	Water Quality Modification		_		_	_	-	-	-
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, an fitness at larval and juvenile lift history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

y			Ex	posure	Υ.	r			The 1/1 Tree / 0/7
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
C	reation/Restoratio	n/Enhancement							
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	 <u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-histo stages, depending on project-speci noise intensity and receptor expose Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	J <mark>uveni</mark> les; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is curren data gap.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Juveniles</u> : Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. <u>All exposed life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of juveniles. May affect juvenile survival, growth, and fitness. S effects for related stressors und Water Quality Modification.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification		-	-	-	-			
	Marine		-		_				
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life history stages.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval rockfish settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat. This may occur through a		
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous	,			
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		direct mortality.		
	Ecosystem Fragmentation								
	Marine	1	1	1	1		1	1	1
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

ıb-			Ex	posure					
tivity 7pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification		-		-	-		-	-
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life- history stages.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Larvae; Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of larvae, juveniles, and adults.
el Gr reati	ass and Other Aqu on/Restoration/Enl	natic Vegetation hancement							
	Construction and Maintenance Activities								
	Marine								

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Table A-20	(continued).
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HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-			Exj	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Adhere to system-specific in-water work windows.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-21. HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Mechanism of Impact r Dam Removal	Stressor	When	Duration	Frequency	Life-history Form			Resulting Effects of the
r Dam Removal				1 0	Life-instory Form	Response to Stressor	Minimization Measures	Submechanism
Not applicable								
Woody Debris								
nent/Movement/Re	emoval (for placement							
onstruction impact	ts appry)							
Construction and Maintenance Activities								
Marine								
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Veliger larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	<u>All life-history stages</u> : Effect of anthropogenic sound is a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Effect of increased ambient no level on Olympic oyster is a da gap.

Sub-			Ex	posure	1	γ		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Veliger larvae; Juveniles; Adults;	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoi ripar shore prop
	Hydraulic and Geomorphic Modification				I			
	Marine		-					
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Care desig impa proje desig sedin
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for Olympia oyster. This may occur through a number of specific stressors, including food work alterations and	patte patte
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Alteration of circulation patterns may	
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		also affect spawn timing and the transport and settlement of veliger larvae. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of parian vegetation. Limit bank, preline and benthic disturbance. Use oper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and current tterns.	May affect survival, growth, and fitness at all life-history stages.

Sub-			Ex	posure				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Ecosystem Fragmentation	-				-		-
	Marine							
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Veliger larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : LWD removal in the marine environment can fragment nearshore habitat and may limit the area suitable for larval settlement, decreasing overall juvenile and adult abundance.	Requ footp objec in an effec
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Enco perm habit
	Aquatic Vegetation Modification							
	Marine							
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Reduced feeding opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Cons</u> distu durir
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	

Minimization Measures	Resulting Effects of the Submechanism
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect larval survival, in turn affecting juvenile and adult population abundance.
acourage project designs that limit rmanent alteration of high-quality bitat features.	May affect juvenile survival.
onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	May affect juvenile growth and fitness.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile survival. May affect adult growth and fitness.

Sub-			Ex	posure	.	1				
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor			
	Riparian Vegetation Modification									
	Marine									
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	Juveniles and adults: Although, riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors, Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other species.	Avo ripai appr the ş		
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Juveniles and adults: Burial can smother Olympia oysters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described in Water Quality Modification.	Avor ripar appr the g		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	J <mark>uveniles;</mark> Adults	Juveniles and adults: Olympia oyster dependence on allochthonous and autochthonous inputs from marine riparian vegetation is a data gap.	Avo ripar appr the g		
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased food resources, leading to adverse effects on growth and fitness.	Enco perm habi		
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Veliger larvae; Juveniles: Adults	<u>All life history stages</u> : Olympia oyster are known to prefer areas where freshwater seepage into the intertidal zone likely limits extremes in temperature.	Avo shor		

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).
yoid/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May affect juvenile and adult survival.
yoid/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	Effects of this impact mechanism and related stressors are currently a data gap.
acourage project designs that limit rmanent alteration of high-quality bitat features.	May affect juvenile survival, adult spawning success, and overall population productivity.
void disturbance of vegetation along oreline.	Effects from this impact mechanism may also include protection from predators unable to tolerate low salinity habitats.

Sub- activity									
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor		
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensur minin to chr short- backg practi protoc	
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensur drasti comp	
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Olympia oyster dissolved oxygen effect thresholds are currently a data gap. Sensitivity to dissolved oxygen levels appears to be low, however.	Ensur drasti comp	
spawr	ning Substrate Aug	mentation							
	Not applicable								
n-Ch		Habitat Creation/Modific	ation						
	Not applicable								
Ripari	an Planting/Restor	ation Enhancement							
	Construction and Maintenance Activities								
	Marine	1	1						
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : Although, riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors, Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other spacies	Minir specie assure specie	

cause mortality in other species.

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.
sure project design does not astically reduce hydraulic mplexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.
sure project design does not astically reduce hydraulic mplexity or impact riparian buffers.	May affect survival of incubating larvae, juveniles, and adults. May affect juvenile and adult survival, growth, and fitness, including adult spawning success. Actual effects are unknown, as sensitivity to this stressor and effects thresholds are currently data gaps.
inimize disturbance during invasive eccies removal. Use measures to sure rapid establishment of planted eccies.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).

Sub-			_					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Veliger larvae; Juveniles;	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Mini speci erosi after
	Aquatic Vegetation Modification							
	Marine							
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Desig canoj conti

Minimization Measures	Resulting Effects of the Submechanism
inimize disturbance during invasive eccies removal. Use appropriate osion control BMPs both during and er construction.	See effects for related stressors under Water Quality Modification.
esign riparian patches with variable nopy coverage so that sunlight will ntinue to reach the water surface.	May affect juvenile survival. May affect adult growth and spawning productivity.

Sub-			Fv	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification	-		-		-		-	-
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : Although, riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors, Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other species.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.

Sub-Exposure activity **Mechanism of Impact** Stressor When Duration Frequency Life-history Form **Response to Stressor** Туре Wetland Creation Restoration/Enhancement **Construction and Maintenance Activities** Marine Equipment Operation Elevated Hydrocarbons (associated During project Temporary to short-Interannual to Veliger larvae All life-history stages: Physiological Ref with potential fuel and oil spills) construction activities decadal responses to exposure at toxic levels, causing term cor Juveniles; mortality or injury leading to reduced fitness. wat Adults Bioaccumulation of contaminants at subacute wo levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. During project Veliger larvae; All life-history stages: Effect of Elevated noise, visual, physical Temporary (auditory Interannual to Av anthropogenic sound is a data gap. disturbance construction and masking) to shortdecadal (during Juveniles, im NC maintenance activities term (hearing project construction Adults threshold effects) hał and maintenance) driv Use red cor End and Lin ma Veliger larvae; All life-history stages: See responses to Bank, Channel, Shoreline Increased suspended solids Av Year-round (with Intermediate-term to Continuous to Disturbance specific stressors long-term (dependent seasonal (dependent related stressors under Water Quality Juveniles; ripa prominent during high on time required for on specific stressor) Modification. sho Adults flow conditions) pro riparian recovery) Water Quality Modification

Minimization Measures	Resulting Effects of the Submechanism
efuel and service machinery in a ontrolled environment away from the ater body. Limit heavy machinery ork within the project area.	May affect survival, growth, and fitness of juveniles and adults.
void pile-driving noise in excess of npact thresholds established by OAA Fisheries and USFWS in abitats used by species. Limit pile tiving to in-water work windows. se double-confined bubble curtain to duce sound pressure, or work within onfined or dewatered work areas. ncourage use of vibratory hammers ad wooden pilings where practicable. timit in-water use of heavy achinery.	Effect of increased ambient noise level on Olympic oyster is a data gap.
void/minimize disturbance of parian vegetation. Limit bank, toreline and benthic disturbance. Use oper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

-			Exj	posure	·				
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
ach	Nourishment/Cont	ouring							
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality from burial. Decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of all life history stages. May affect juvenile survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of juveniles	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality from burial. Decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of all life history stages. May affect juvenile survival, growth, and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased habitat availability and feeding opportunities, leading to increased competition and predation	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of	May affect juvenile survival. Ma affect adult growth and spawning productivity.

Marine										
Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of juveniles	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality from burial. Decreased growth and fitness.	Avo proc com			
Aquatic Vegetation Modification										
Marine										
Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased habitat availability and feeding opportunities, leading to	Avo vege			

			Ex	posure	r							
,	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Altered cover and habitat	Reduced cover					exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	productive, vegetated aquatic habitat.				
	Water Quality Modification											
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.			
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.			
C	reation/Restoratio	n/Enhancement										
	Construction and Maintenance Activities											
ľ	Marine											
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	<u>All life-history stages</u> : Effect of anthropogenic sound is a data gap.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	Effect of increased ambient no level on Olympic oyster is a da gap.			
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Veliger larvae; Juveniles, Adults	<u>All life-history stages</u> : Effect of anthropogenic sound is a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	Effect of increased ambient no level on Olympic oyster is a da gap.			
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults;	All life-history stages: Mortality from burial. Decreased growth and fitness. See responses described for related stressors under Water Quality	Avoid project site which are productive and have a healthy benthic community.	May affect veliger larvae productivity and fitness. See effects for related stressors un Water Quality Modification.			

Construction and Maintenance Activities										
Marine										
Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	<u>All life-history stages</u> : Effect of anthropogenic sound is a data gap.	Avoi perio prese			
Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Veliger larvae; Juveniles, Adults	<u>All life-history stages</u> : Effect of anthropogenic sound is a data gap.	Avoi noise equip techr			
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults;	All life-history stages: Mortality from burial. Decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoi produ comr			

Sub-			Exj	posure	T	T						
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	Hydraulic and Geomorphic Modification											
	Marine											
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Veliger larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for Olympia oyster. This may occur through a number of specific stressors,	Caref desig impac proje desig sedin				
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal			patte patte				
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent	0	including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Alteration of circulation patterns may also affect spawn timing and the transport and settlement of veliger larvae. The					
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.					
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous							
	Ecosystem Fragmentation											
	Marine											
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoi proxi corrie preda				

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on liment supply, longshore drift tterns, and wave energy and current tterns.	May affect survival, growth, and fitness at all life-history stages.
yoid placement of reef projects in poximity to juvenile migratory rridors, such that increased edation exposure may occur.	May affect juvenile survival, growth and fitness.

Sub-			Ex	posure								
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	Aquatic Vegetation Modification	-			-		-					
	Marine											
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles</u> : Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid veget				
	Water Quality Modification											
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Carefr design impac projec design sedim patter patter				
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Veliger larvae; Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use n				

Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement

Construction and Maintenance Activities											
Marine											
Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles, Adults	<u>All life-history stages</u> : Effect of anthropogenic sound is a data gap.	Adhe work				
Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality.	Avoi abov exten estab sedin				

Resulting Effects of the Submechanism
May affect juvenile growth and fitness.
May affect juvenile and adult survival.
May affect survival and productivity of larvae, juveniles, and adults.
Effect of increased ambient noise level on Olympic oyster is a data gap.
May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.

Table A-22. HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

r.			Ex	posure	· [1	4		Dogulting Efforts of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
er	Dam Removal								
	Not applicable								
e V	Woody Debris								
m	ent/Movement/Re	moval (for placement							
<u>co</u>	nstruction impacts	s apply)							
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term Temporary (auditory	Interannual to decadal Interannual to	Larvae; Juveniles; Adults Juveniles;	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Juveniles and adults: Effect of	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults. Effect of anthropogenic sound
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	masking) to short- term (hearing threshold effects)	decadal (during project construction and maintenance)	Adults	anthropogenic sound on northern abalone is a data gap.	Avoid pile-driving holse in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	northern abalone is a data gap
1		1			T	1	1	1 *	1

Minimization M	leasures
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Sub-			Ex	posure	r	1	4					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avo ripar shor prop				
	Hydraulic and Geomorphic Modification	eomorphic Modification										
	Marine											
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Care desig impa proje desig sedin				
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for northern abalone. This may occur through a number of specific stressors, including food web alterations and	patte patte				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Loss of marine macroalgae may increase the					
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		visibility of the northern abalone to predators. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.					

Table A-22 (continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of parian vegetation. Limit bank, preline and benthic disturbance. Use oper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and current tterns.	May affect survival at all life- history stages.

		Exposure							
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-	-	-	-
	Marine								
_	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : The structural footprint of groins and bank barbs may eliminate suitable habitat for larval settlement and juvenile and adult foraging. Over time, increased hard surface area associated with structures may increase the amount of surface area available for abalone foraging, but these beneficial effects may be offset by stressors related to hydraulic and geomorphic modification.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, in turn affecting juvenile and adult population abundance.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
-	Marine	[]					Lucesiles and edulter Newthern sheless		Effect from this import we show in
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Northern abalone dependence on allochthonous and autochthonous inputs from marine aquatic vegetation is a data gap. Northern abalone are known to use intertidal and subtidal vegetation and phytoplankton that could be a product of aquatic vegetation autochthonous input.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	Effect from this impact mechanis is currently a data gap.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
-	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge and rearing habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity.		May affect juvenile growth, fitness, and survival. May affect adult growth and spawning productivity.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

	Exposure							
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Riparian Vegetation Modification		-			-			
Marine								
Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	Juveniles and adults: The effect of riparian shading on abalone is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Effects of this impact mechanism and related stressors are currently a data gap.
Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Juveniles and adults: Burial can smother northern abalones if large pulses of landslide debris were to enter Puget Sound waters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival.
Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Northern abalone dependence on allochthonous and autochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	Effects of this impact mechanism and related stressors are currently a data gap.
Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Northern abalone dependence on LWD related habitat complexity is currently a data gap.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Effects of this impact mechanism and related stressors are currently a data gap.
Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Larvae; Juveniles: Adults	<u>All life history stages</u> : Northern abalone dependence nearshore groundwater input is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of this impact mechanism and related stressors are currently a data gap.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-								
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modification	-		-	-	-	-	_
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensur minin to chr short- backg practi proto- turbic
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles	All exposed life history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensur drasti comp
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. <u>Juveniles and adults</u> : Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensur drasti comp

Table A-22 (continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Spawning Substrate Augmentation

Not applicable

In-Channel/Off-Channel Habitat Creation/Modification

Not applicable

Riparian Planting/Restoration Enhancement

Construction and Maintenance Activities							
Marine							
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles and adults: The effect of riparian shading on abalone is currently a data gap.	Minim species assure species

Minimization Measures	Resulting Effects of the Submechanism
insure project design avoids and/or inimizes habitat alterations leading o chronic bank instability. Avoid hort-term turbidity effects above ackground levels to greatest extent racticable. Adhere to established rotocols for managing sediment and urbidity.	May affect survival and productivity of all life-history stages.
nsure project design does not rastically reduce hydraulic omplexity or impact riparian buffers.	May affect survival and productivity of larvae and juveniles.
nsure project design does not rastically reduce hydraulic omplexity or impact riparian buffers.	May affect survival of all life- history stages.
finimize disturbance during invasive pecies removal. Use measures to ssure rapid establishment of planted pecies.	Effects of this impact mechanism and related stressors are currently a data gap.

Sub-			Ex	posure	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Mini speci erosi after
	Aquatic Vegetation Modification		1	1	1			
	Marine							
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Northern abalone dependence on allochthonous and autochthonous inputs from marine aquatic vegetation is a data gap. Northern abalone are known to use intertidal and subtidal vegetation and phytoplankton that could be a product of aquatic vegetation autochthonous input.	Desig canoj conti

Table A-22 (continued).HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Minimization Measures	Resulting Effects of the Submechanism
inimize disturbance during invasive ecies removal. Use appropriate osion control BMPs both during and ter construction.	See effects for related stressors under Water Quality Modification.
esign riparian patches with variable nopy coverage so that sunlight will ntinue to reach the water surface.	Effect from this impact mechanism is currently a data gap.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification			-	-	-	-	-	-
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge and rearing habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth, fitness, and survival. May affect adult growth and spawning productivity.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : The effect of riparian shading on abalone is currently a data gap.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	Effects of this impact mechanism and related stressors are currently a data gap.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival and productivity of all life-history stages.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

		Ex	posure	r	· · · · · · · · · · · · · · · · · · ·	4		
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
and Creation Rest	oration/Enhancement							
Construction and Maintenance Activities								
Marine								
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Effect of anthropogenic sound on northern abalone is a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Effect of anthropogenic sound northern abalone is a data gap.
Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors u Water Quality Modification.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Table A-22 (continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

			Ex	posure	ï	Ť.	-		
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity of all life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Larvae; Juveniles	All exposed life history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival and productivity of larvae and juveniles.
h I	Nourishment/Cont	touring							
	Construction and								
	Maintenance Activities								
	Maintenance Activities Marine								
		Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
-	Marine					Juveniles;	responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or	controlled environment away from the water body. Limit heavy machinery	
-	Marine Equipment Operation Bank, channel, shoreline	with potential fuel and oil spills) Localized alteration in invertebrate abundance from burial, increased	construction activities During project construction and	term	decadal Interannual to decadal (depending on activity	Juveniles; Adults Larvae; Juveniles;	responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. <u>All life-history stages</u> : Mortality from	 controlled environment away from the water body. Limit heavy machinery work within the project area. Avoid project site which are productive and have a healthy benthic 	fitness of juveniles and adults. May cause direct mortality of a life history stages. May affect juvenile survival, growth, and
	Marine Equipment Operation Bank, channel, shoreline disturbance	with potential fuel and oil spills) Localized alteration in invertebrate abundance from burial, increased	construction activities During project construction and	term	decadal Interannual to decadal (depending on activity	Juveniles; Adults Larvae; Juveniles;	responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. <u>All life-history stages</u> : Mortality from	 controlled environment away from the water body. Limit heavy machinery work within the project area. Avoid project site which are productive and have a healthy benthic 	fitness of juveniles and adults. May cause direct mortality of a life history stages. May affect juvenile survival, growth, and
	Marine Equipment Operation Bank, channel, shoreline disturbance Hydraulic and Geomorphic Modification	with potential fuel and oil spills) Localized alteration in invertebrate abundance from burial, increased	construction activities During project construction and	term	decadal Interannual to decadal (depending on activity	Juveniles; Adults Larvae; Juveniles;	responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. <u>All life-history stages</u> : Mortality from	 controlled environment away from the water body. Limit heavy machinery work within the project area. Avoid project site which are productive and have a healthy benthic 	fitness of juveniles and adults. May cause direct mortality of a life history stages. May affect juvenile survival, growth, and fitness. May cause direct mortality of all 1
	Marine Equipment Operation Image: Comparison of the second of	with potential fuel and oil spills) Localized alteration in invertebrate abundance from burial, increased suspended solids Localized alteration in invertebrate abundance from burial, burial of	construction activities During project construction and maintenance activities During project construction and	term Short-term Short-term – long-	decadal Interannual to decadal (depending on activity frequency) Interannual to decadal (depending on activity	Juveniles; Adults Larvae; Juveniles; Adults Larvae; Juveniles;	responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. <u>All life-history stages</u> : Mortality from burial. Decreased growth and fitness. <u>All life-history stages</u> : Mortality from	 controlled environment away from the water body. Limit heavy machinery work within the project area. Avoid project site which are productive and have a healthy benthic community. Avoid project site which are productive and have a healthy benthic 	fitness of juveniles and adults. May cause direct mortality of a life history stages. May affect juvenile survival, growth, and fitness. May cause direct mortality of all 1 history stages. May affect juvenil
	Marine Equipment Operation Equipment Operation Bank, channel, shoreline disturbance Hydraulic and Geomorphic Modification Marine Altered sediment supply Aquatic Vegetation	with potential fuel and oil spills) Localized alteration in invertebrate abundance from burial, increased suspended solids Localized alteration in invertebrate abundance from burial, burial of	construction activities During project construction and maintenance activities During project construction and	term Short-term Short-term – long-	decadal Interannual to decadal (depending on activity frequency) Interannual to decadal (depending on activity	Juveniles; Adults Larvae; Juveniles; Adults Larvae; Juveniles;	responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. <u>All life-history stages</u> : Mortality from burial. Decreased growth and fitness. <u>All life-history stages</u> : Mortality from	 controlled environment away from the water body. Limit heavy machinery work within the project area. Avoid project site which are productive and have a healthy benthic community. Avoid project site which are productive and have a healthy benthic 	fitness of juveniles and adults. May cause direct mortality of a life history stages. May affect juvenile survival, growth, and fitness. May cause direct mortality of all I history stages. May affect juvenil

Geomorphic Modification	L						
Marine							
Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of juveniles	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality from burial. Decreased growth and fitness.	Av pro cor
Aquatic Vegetation Modification							
Marine							
Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge and rearing habitat availability and food resource availability, leading to increased	Av veg Av

-			Ex	posure	<u>[</u>				
ity	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced cover					competition and predation exposure and resulting in decreased survival, growth, and fitness.	productive, vegetated aquatic habitat.	productivity.
							<u>Adults</u> : Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity of all life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Larvae; Juveniles	All exposed life history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival and productivity of larvae and juveniles.
ef C	reation/Restoratio	n/Enhancement							
	Marine				T. 1.	· ·			
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival, growth, and fitness of juveniles and adults.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Juveniles and adults: Effect of anthropogenic sound on northern abalone is a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	Effect of anthropogenic sound or northern abalone is a data gap.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Mortality from burial. Decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid project site which are productive and have a healthy benthic community.	May affect larvae productivity at fitness. See effects for related stressors under Water Quality Modification.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Construction and Maintenance Activities							
Marine							
Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avo perio preso
Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Juveniles and adults: Effect of anthropogenic sound on northern abalone is a data gap.	Avo nois equi tech
Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Mortality from burial. Decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avc proc

ub-			Ex	posure					
ctivity ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification			-					-
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect survival at all life- history stages.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for northern abalone. This may occur through a number of specific stressors, including food web alterations and	patterns, and wave energy and current patterns.	
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Loss of marine macroalgae may increase the visibility of the northern abalone to predators. The combined effect of these		
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.		
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growtl and fitness.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-Exposure activity Туре **Mechanism of Impact** Stressor When Duration Frequency Life-history Form **Response to Stressor Aquatic Vegetation** Modification Marine Altered cover and habitat Decreased refuge and forage habitat Year-round Short-term to Continuous Juveniles <u>Juveniles:</u> Decreased refuge habitat Av availability and foraging opportunities, permanent veg leading to increased competition and (dependent on nature predation exposure, resulting in of activity) decreased survival, growth, and fitness. Water Quality Modification Larvae; <u>All life-history stages</u>: Responses vary Altered suspended solids Increased suspended solids Dependent on Temporary to short-Ca Intermittent to depending on stressor magnitude. contributing term (dependent on interannual-decadal des Juveniles; Unavoidable extreme turbidity may cause mechanism of impact contributing (dependent on im mortality or hinder feeding. Adults mechanism of contributing pro impact) mechanism of des impact) sed pat pat Use All affected life-history stages: Leaching of toxic substances Altered pollutant loading Continuous with Year-round Intermediate-term Larvae: (depending on composition of reef seasonal pulses Physiological responses to exposure at Juveniles; material) (dependent on toxic levels, causing mortality or injury Adults leading to reduced fitness. current velocity) Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.

HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone. Table A-22 (continued).

Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement

Construction and Maintenance Activities							
Marine							
Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles, Adults	<u>All life-history stages</u> : Effect of anthropogenic sound is a data gap.	Adh work
Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality.	Avoi abov exter estat sedir

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of aquatic egetation during project construction.	May affect juvenile growth and fitness.
arefully evaluate project siting and esign and consider the magnitude of npact mechanisms produced by the roject. Encourage selection of project esigns that minimize effects on ediment supply, longshore drift atterns, and wave energy and current atterns.	May affect survival and productivity of all life-history stages.
se non-toxic reef material.	May affect survival and productivity of larvae, juveniles, and adults.
dhere to system-specific in-water ork windows.	Effect of anthropogenic sound on northern abalone is a data gap.
void short-term turbidity effects pove background levels to greatest stent practicable. Adhere to stablished protocols for managing ediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.

r			Ex	posure]		_		Resulting Effects of the
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Forn	n Response to Stressor	Minimization Measures	Submechanism
ver 1	Dam Removal								
I	Not applicable								
ge W eme con	Voody Debris ent/Movement/Ren struction impacts	moval (for placement s apply)							
	Construction and Maintenance Activities								
Ν	Marine								
I	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Unknown	Unknown	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	Unknown
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Unknown	Unknown	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Unknown
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Unknown	Unknown	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Unknown

Table A-23. HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

(continued).

HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

,			Ex	posure		- <u>r</u>			D 1/1 700 / 0.1			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Marine											
-	Altered wave energy Altered current velocities	Change in habitat structure and habitat suitability; reduced food web	Year-round Year-round (with	Permanent Permanent	Continuous	Unknown	<u>All life-history stages</u> : Wave energy, sediment supply, substrate composition,	Carefully evaluate project siting and design and consider the magnitude of	May affect survival, growth, a fitness at all life-history stages			
	Anered current velocities	complexity, habitat availability, and suitability	variable effects depending on site- specific current dynamics and project configuration)	I emanent	Internation		and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially	impact mechanisms produced by the project. Encourage selection of projec designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	However, actual effects are			
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous		altering the extent and composition of <i>Salicornia</i> habitat for Newcomb's littorine snail. In particular, alteration of littoral wave energy and sediment	patterns.				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime,	Permanent	Continuous		characteristics could lead to reductions in the amount of <i>Salicornia</i> habitat, or more frequent inundation leading to reduced habitat suitability. These alterations could lead to reduced survival, growth, and fitness; however, life-history specific sensitivity to these stressors is currently a data gap. As Newcomb's littorine snail is not a truly aquatic species and spends					
_	Ecosystem Fragmentation		routine grounding, anchor trenching])				little time below the water surface, it is not affected by changes in current and circulation patterns.	s				
H	Marine											
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Unknown	The importance of LWD to Newcomb's littorine snail is currently a data gap, therefore the effects of stressor exposure are unknown. However, except for the potential effects of this impact mechanism on the quantity and quality of available <i>Salicornia</i> habitat, the effects of this stressor are likely limited.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	The effects of exposure to this stressor are unknown, but are likely to be insignificant.			
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Unknown	The importance of LWD to Newcomb's littorine snail is currently a data gap, therefore the effects of stressor exposure are unknown. However, except for the potential effects of this impact mechanism on the quantity and quality of available <i>Salicornia</i> habitat, the effects of this stressor are likely limited.	Encourage project designs that limit permanent alteration of high-quality habitat features.	The effects of exposure to this stressor are unknown, but are likely to be insignificant.			

Table A-23 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-			Ex	posure	1	·						
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	Aquatic Vegetation Modification	-										
	Marine											
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Unknown	Unknown	<u>Con</u> distu duri				
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Unknown	Unknown					
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Unknown	Unknown					
	Riparian Vegetation Modification											
	Marine											
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Unknown	Newcomb's littorine snail it is an intertidal mollusk species that lives under and on the stems of glasswort (<i>Salicornia</i> <i>virginica</i>), which occurs in narrow bands on the fringes of salt marshes. Little is known of the life-history of this species, although its limited distribution and dependence on specific vegetation types increases sensitivity to specific types of riparian impacts. <i>Salicornia</i> fringe habitats are typically less influenced by	Avo ripai appr the ş				
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Unknown	riparian shade, but the actual shade requirements and life-history specific temperature requirements of this species are unknown. While tolerant of both salt and fresh water, it avoids immersion for long periods and will drown if trapped.	Avo ripar appr the s				
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Unknown	Actual dependence on freshwater inflow is a data gap. However, salt marsh habitats in general are shaped by combined surface and ground water flows; therefore, alteration of freshwater	Avor ripar appr the g				

Minimization Measures	Resulting Effects of the Submechanism
onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	Unknown
	Unknown
	Unknown
void/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	Riparian vegetation modification leading to the alteration of <i>Salicornia</i> habitat in salt marsh environments where this species occurs is likely to lead to reduced survival, growth, and fitness at one or more life-history stages. Effects resulting from exposure to specific impact mechanisms are unknown, however, as sensitivity to stressor
woid/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	exposure and life-history requirements are a data gap.
void/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	

HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-								
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Unknown	inflow may lead to reduction in suitable habitat area.	Enco perm habit
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Unknown		Avoi shore
	Water Quality Modification							
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Unknown	Unknown	Ensu minit to ch short backg pract proto turbid
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Unknown	Unknown	Ensu: drasti comp
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Unknown	Unknown	Ensu: drasti comp
Spawn	ing Substrate Aug	mentation						
	Not applicable							
In-Cha	nnel/Off-Channel	Habitat Creation/Modific	ation					
	Not applicable							
Riparia	an Planting/Restor	ation Enhancement						
	Construction and Maintenance Activities							
	Marine							

Minimization Measures	Resulting Effects of the Submechanism
courage project designs that limit manent alteration of high-quality bitat features.	
oid disturbance of vegetation along oreline.	
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	Unknown
sure project design does not stically reduce hydraulic nplexity or impact riparian buffers.	Unknown
sure project design does not stically reduce hydraulic nplexity or impact riparian buffers.	Unknown

HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-			Ex	posure	1			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Unknown	Unknown	Mini speci assur speci
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Unknown	Unknown	Mini speci erosi after
	Aquatic Vegetation Modification							
	Marine		T			I	1	
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Unknown	Unknown	Desi cano conti

Minimization Measures	Resulting Effects of the Submechanism
inimize disturbance during invasive eccies removal. Use measures to sure rapid establishment of planted eccies.	Unknown
inimize disturbance during invasive eccies removal. Use appropriate osion control BMPs both during and er construction.	Unknown
esign riparian patches with variable nopy coverage so that sunlight will ntinue to reach the water surface.	Unknown

Table A-23 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

•		Exposure							
rity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification			-		-			
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Unknown	Unknown	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	Unknown
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Unknown	Unknown	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	Unknown
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Unknown	Unknown	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	Unknown

Table A-23 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-											
activity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor				
Vetlar	nd Creation Restor	ation/Enhancement									
	Construction and Maintenance Activities										
	Marine										
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Unknown	Unknown	Ref con wat wor			
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Unknown	Unknown	Avo imp NO2 habi driv Use redu conf Encc and Lim mac			
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Unknown	Unknown	Avo ripas shor prop			
	Water Quality Modification										

Minimization Measures	Resulting Effects of the Submechanism
efuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the project area.	Unknown
yoid pile-driving noise in excess of pact thresholds established by DAA Fisheries and USFWS in bitats used by species. Limit pile iving to in-water work windows. See double-confined bubble curtain to duce sound pressure, or work within nfined or dewatered work areas. accourage use of vibratory hammers d wooden pilings where practicable. mit in-water use of heavy achinery.	Unknown
void/minimize disturbance of parian vegetation. Limit bank, preline and benthic disturbance. Use oper erosion control BMPs.	Unknown

HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-			Ex	posure			_	
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Unknown	Unknown	Ensur minin to chr short- backg practi protoo turbic
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Unknown	Unknown	Refue contro water work
Beach	Nourishment/Cont	touring						
	Not applicable							
Reef C	Creation/Restoration	n/Enhancement						
	Not applicable							
Eel Gr Creati	ass and Other Aquon/Restoration/Enl Construction and	atic Vegetation hancement						
	Maintenance Activities Marine							
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Unknown	Unknown	Adher work
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Unknown	Unknown	Avoid above exteni establ sedim

Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	Unknown
fuel and service machinery in a ntrolled environment away from the ater body. Limit heavy machinery ork within the channel.	Unknown
lhere to system-specific in-water ork windows.	Unknown
void short-term turbidity effects ove background levels to greatest tent practicable. Adhere to ablished protocols for managing diment and turbidity.	Unknown

			Ex	posure		ŕ			
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
er	Dam Removal								
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: The effects of elevated levels of anthropogenic noise on the Columbia River limpet and Columbia River spire snail are a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	The effects of pile-driving sounds other anthropogenic sounds to Columbia River limpet and Colum River spire snail are a data gap.
	Impoundment dewatering	Stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : Mortality from dewatering.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	Mortality and reduced surviva productivity at affected life-hi stages.
		Localized decrease in periphyton coverage	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	J <mark>uvenil</mark> es; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and productivity at juvenile life-hi stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors un Water Quality Modification.
	Hydraulic and Geomorphic Modification								
_	Riverine								
Ge Ri Al	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Juveniles; Adults	<u>All life-history stages</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project.	May affect all life-history stag decreased growth, survival, an productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high- flow events, fall through spring)	Intermediate-term to long-term	Seasonal		decreased survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability and changes in food web complexity.	Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the	
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal		This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth,	greatest extent practicable.	
	Altered substrate composition (including gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous		fitness, and survival. <u>Adults</u> : Changes in channel morphology		

		Exposure							
y Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor			
Altered groundwater- surface water exchange		Year-round	Intermediate-term to long-term	Continuous		may lead to habitat alteration, leading to increased stress and predation rate. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity.			
Ecosystem Fragmentation									
Riverine									
Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen Decreased dissolved oxygen from	Year-round (most pronounced in summer and autumn when vegetation growth and decay is	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and Adults</u> : See related stressor responses under Water Quality Modification.	Avo thro		
	eutrophication below the impoundment (caused by elevated nutrient export)	most extensive)							
	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Avc thro		
Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased prey resource availability leading to increased competition, and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality and decreased fitness	Req hyd befo peri disc hab		
Aquatic Vegetation Modification		1							
Riverine									
Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased prey resource availability leading to increased competition, and resulting effects on growth and fitness.	Avo thro		
			-			<u>Adults:</u> Increased mortality and decreased fitness			
Riparian Vegetation Modification									
Riverine									

Minimization Measures	Resulting Effects of the Submechanism
void draining impounded area rough use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
void draining impounded area rough use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.
equire assessment of the draulic effects of the project fore permitting and avoid rmitting designs that lead to sconnection of floodplain bitat.	May affect juvenile and adult survival and productivity.
roid draining impounded area rough use of beaver deceivers.	May affect juvenile and adult survival and productivity.

lb- tivity			Ex	posure		<u> </u>	4	
pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered stream bank and shoreline stability	Increased suspended solids Increased sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Avoi ripar syste widti possi
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced prey resource availability due to decreased food web productivity; decreased growth and fitness.	Avoi ripar syste widt possi
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Repl nativ invas
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.	Repl nativ invas
	Water Quality Modification							
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensur minin to chu short backg pract proto turbio
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refue envir area. comp

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of parian vegetation. Maintain stem-appropriate riparian buffer dths to the greatest extent pssible.	May affect survival and productivity.
void/minimize disturbance of parian vegetation. Maintain stem-appropriate riparian buffer dths to the greatest extent ssible.	May affect juvenile and adult life- history stages.
eplant former impoundment with tive vegetation to discourage vasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
eplant former impoundment with tive vegetation to discourage vasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May decrease survival and productivity.
fuel machinery in a controlled vironment away from the project ea. Avoid reducing hydraulic mplexity.	May affect survival, growth, and fitness of juveniles and adults.

			Ex	posure					
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All life-history stages:</u> Requires high dissolved oxygen content. Mortality, decreased fitness, growth, and survival.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect productivity and surviva of all life-history stages.
col	nstruction impact Construction and Maintenance Activities	emoval (for placement is apply)							
	Riverine					•			
	Equipment Operation	Elevated Hydrocarbons (associated	During project	Temporary to short-	Interannual to	Juveniles;	All life-history stages: See responses to	Refuel and service machinery in a	May affect survival, growth, and
		with potential fuel and oil spills)	construction activities	term	decadal	Adults	related stressors under Water Quality Modification.	controlled environment away from the water body. Limit heavy machinery work within the project area.	fitness of juveniles and adults.

rity			Ex	posure	1	1	-		Resulting Effects of the
ny e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Mortality and reduced survival an productivity at affected life-histor stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	These species' potential for entrainment in pumps or impingement on pump screens is data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect growth and productivity at all life-history stages.
		Localized decrease in periphyton coverage	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and productivity at juvenile life-histor stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Juveniles; Adults	<u>All life-history stages:</u> Mortality from entrainment and decreased prey availability resulting in decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect all life-history stages; decreased fitness, growth and survival of affected stages. See effects for related stressors under Water Quality Modification.

b-													
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor						
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All life-history stages</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to	Care and mag prod					
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		decreased survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability and changes in food web complexity.	Enco desig char subs grou					
	Altered substrate composition		Year round	Permanent	Continuous		This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth,	grea					
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		Adults: Changes in channel morphology may lead to habitat alteration, leading to increased stress and predation rate. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity.						
	Ecosystem Fragmentation												
	Riverine	1		1				1					
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and Adults</u> : See related stressor responses under Water Quality Modification.	Req hydi befo					
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.						
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juvenile and adults</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Req hydr befo desi of fl long					
	Altered longitudinal habitat connectivity												

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting d design and consider the agnitude of impact mechanisms oduced by the project. acourage selection of project signs that minimize effects on annel geometry, flow velocity, bstrate composition, and oundwater exchange to the eatest extent practicable.	May affect all life-history stages; decreased growth, survival, and productivity.
equire assessment of the draulic effects of the project fore permitting	See effects for related stressors under Water Quality Modification.
	May affect survival, growth, and fitness of juveniles and adults.
equire assessment of the draulic effects of the project fore permitting; avoid permitting signs that lead to disconnection floodplain habitat or ngitudinal reach simplification.	May affect juvenile and adult productivity and survival.

Sub-			4							
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor			
	Altered autochthonous production	Reduced food web productivity	sduced food web productivityYear-round (most pronounced in spring and summer when vegetation growth is 	Continuous	Juveniles; Adults	<u>Juvenile and adults</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	<u>Con</u> distu durii			
		Altered dissolved oxygen levels due to reduced photosynthesis	pronounced in spring and summer when vegetation growth is	Permanent	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u> : See related stressor responses under Water Quality Alteration.			
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	permanent (dependent on nature	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.			
	Riparian Vegetation Modification									
	Riverine									
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	(pronounced in winter/summer during solar radiation and ambient temperature	permanent (dependent on nature of riparian	Seasonal	Juveniles; Adults	<u>All life-history stages:</u> Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avo ripan syste widt poss		
	Altered stream bank and shoreline stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity	specific stressors prominent during	to long-term (dependent on time required for	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>All life-history stages:</u> Prefers high levels of dissolved oxygen and cool water. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avo ripar syste widt poss		
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round	permanent (dependent on	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased prey resource availability, leading to increased competition and resulting effects on growth and fitness. <u>Adults:</u> Increased mortality and decreased fitness.	Enco limit qual		

Minimization Measures	Resulting Effects of the Submechanism
onstruction: Avoid/minimize sturbance of aquatic vegetation ring project construction.	May affect juvenile and adult productivity and survival.
	See effects for related stressors under Water Quality Modification.
	May affect juvenile and adult survival and productivity.
void/minimize disturbance of parian vegetation. Maintain stem-appropriate riparian buffer dths to the greatest extent ossible.	May affect survival and productivity.
void/minimize disturbance of barian vegetation. Maintain stem-appropriate riparian buffer dths to the greatest extent ssible.	May affect survival and productivity.
acourage project designs that nit permanent alteration of high- ality habitat features.	May affect juvenile survival and overall population productivity.

HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail. Table A-24 (continued).

ıb-			Ex	posure					
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater– surface water exchange	Reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All life-history stages:</u> See related stressor responses under Water Quality Alteration.	Avoid disturbance of vegetation along stream.	See effects for related stressors under Water Quality Modificatio
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All life-history stages:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All life-history stages:</u> Requires high dissolved oxygen content. Mortality, decreased fitness, growth, and survival.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect productivity and surviva of all life-history stages.
awn	ing Substrate Aug	mentation							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: The effects of elevated levels of anthropogenic noise on the Columbia River limpet and Columbia River spire snail are a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	The effects of pile-driving sounds a other anthropogenic sounds to Columbia River limpet and Colum River spire snail are a data gap.

Construction and Maintenance Activities							
Riverine							
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Ref con wat wor
	Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u> : The effects of elevated levels of anthropogenic noise on the Columbia River limpet and Columbia River spire snail are a data gap.	Lin prac win life

Table A-24 (continued).	HPA HCP Habitat Modification Ex	posure and Response Matrix for	r Giant Columbia River Lin	npet and Great Colu
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Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See Wa
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity	Juveniles; Adults	All life-history stages: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when with limited motility are least likely to be present.	Ma all stre
		Localized decrease in periphyton coverage	During project construction activities	Short-term	frequency) Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	fitn Ma pro stag
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>All life-history stages:</u> Mortality from entrainment and decreased prey availability resulting in decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	Ma dec sur effe Wa
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Intermediate-term	Continuous	Juveniles; Adults	<u>All life-history stages</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project.	Ma dec pro

lumbia River Spire Snail.

Minimization Measures	Resulting Effects of the Submechanism
void/minimize disturbance of parian vegetation. Limit bank, oreline and benthic disturbance. Use oper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
estrict in-water work window to riods when with limited motility are ast likely to be present.	May cause direct mortality or injury at all life-history stages. Injury and stress may affect survival, growth, and fitness.
mit area of dewatering to the eatest extent practicable. Use beaver ceivers to limit hydraulic alteration.	May affect growth and productivity at juvenile life-history stage.
void turbidity effects above ckground levels.	May affect all life-history stages; decreased fitness, growth and survival of affected stages. See effects for related stressors under Water Quality Modification.
arefully evaluate project siting	May affect all life-history stages:

May affect all life-history stages; decreased growth, survival, and productivity.

Sub-			Ex	posure	1	-1		
activity Гуре	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered substrate composition/stability			Short-term to long- term			decreased survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability and changes in food web complexity. This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to habitat alteration, leading to increased stress and predation rate. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity.	Enc desi cha sub grou grou grea
	Aquatic Vegetation Modification							
	Riverine		-					
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juvenile and adults</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avo proj vege habi
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u> : Decreased foraging opportunity due to decreased food web productivity.	
	Water Quality Modification				- -			
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu envi area com

Minimization Measures acourage selection of project signs that minimize effects on annel geometry, flow velocity, bstrate composition, and oundwater exchange to the eatest extent practicable.	Resulting Effects of the Submechanism
void spawning gravel augmentation ojects in locations where aquatic getation plays a strong role in bitat productivity.	May affect juvenile and adult productivity and survival.
fuel machinery in a controlled vironment away from the project ea. Avoid reducing hydraulic mplexity.	May affect survival, growth, and fitness of juveniles and adults.

Sub- ictivity			Ex	posure	······	4		Doculting Effects of the	
ype	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
n-Cha	annel/Off-Channel	Habitat Creation/Modific:	ation						
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	J <mark>uvenile</mark> s; Adults	<u>All life-history stages</u> : The effects of elevated levels of anthropogenic noise on the Columbia River limpet and Columbia River spire snail are a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	The effects of pile-driving sounds an other anthropogenic sounds to Columbia River limpet and Columbi River spire snail are a data gap.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Mortality and reduced survival ar productivity at affected life-histor stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	These species' potential for entrainment in pumps or impingement on pump screens is data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect growth and productivity at all life-history stages.
		Localized decrease in periphyton coverage	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and productivity at juvenile life-histor stage.

HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail. Table A-24 (continued).

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Juveniles; Adults	<u>All life-history stages:</u> Mortality from entrainment and decreased prey availability resulting in decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect all life-history stages; decreased fitness, growth and survival of affected stages. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (if in- channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
Ripari	an Planting/Restor	ation Enhancement							
	Construction and Maintenance Activities								
	Riverine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>All life-history stages:</u> Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival and productivity.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>All life-history stages</u> : Injury or mortality from burial during gravel placement. See responses to increased suspended solids described for related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival and productivity.

Riverine				Ť.			
Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	All life-history stages: Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Min spec assu spec
	Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>All life-history stages</u> : Injury or mortality from burial during gravel placement. See responses to increased suspended solids described for related stressors under Water Quality Modification.	Min spec eros after

Sub-			Ex	posure			_							
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor							
		Benthic sedimentation – due to removal of invasive riparian species												
	Aquatic Vegetation Modification													
	Riverine													
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juvenile and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Desi cano conti						
	Riparian Vegetation Modification													
	Riverine													
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	<u>Juvenile and adults</u> : Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Desi varia sunl char						
	Water Quality Modification													
	Altered Temperatures	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	<u>All life-history stages:</u> Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Mini speci assur speci						
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All life-history stages:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensu mini to ch short back pract proto turbi						

Minimization Measures	Resulting Effects of the Submechanism
esign riparian patches with variable nopy coverage so that sunlight will	May affect juvenile and adult productivity and survival.
ntinue to reach the channel.	
esign riparian patches with riable canopy coverage so that nlight will continue to reach the annel.	May affect juvenile and adult productivity and survival.
nimize disturbance during invasive ecies removal. Use measures to sure rapid establishment of planted ecies.	May affect survival and productivity.
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May decrease survival and productivity.

			Ex	posure	1	1			
y	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
lan	d Creation Restor	ation/Enhancement							
	Construction and Maintenance Activities								
1	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u> : The effects of elevated levels of anthropogenic noise on the Columbia River limpet and Columbia River spire snail are a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	The effects of pile-driving sounds an other anthropogenic sounds to Columbia River limpet and Columbi River spire snail are a data gap.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Mortality and reduced survival and productivity at affected life-histo stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	These species' potential for entrainment in pumps or impingement on pump screens is data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect growth and productivity at all life-history stages.

Sub- activity			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized decrease in periphyton coverage	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and productivity at juvenile life-history stage.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All life-history stages:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach	Nourishment/Cont	touring							
	Not Applicable								
Reef C	reation/Restoratio	n/Enhancement							
	Not Applicable								
Eel Gr Creatie	ass and Other Aqu on/Restoration/Enl	atic Vegetation hancement							
	Not applicable								

		Ex	posure	1	[4		Resulting Effects of the
Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
r Dam Removal								
Construction and Maintenance Activities								
Riverine								
Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Glochidia larvae; Juveniles, Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
	Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : The effect of elevated anthropogenic noise on California floater and western ridged mussels is a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Very little is known of the effect of elevated anthropogenic noise California floater and western ridged mussels at any life-histor stage.
Impoundment dewatering	Stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : Mortality from dewatering.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	Mortality and reduced survival productivity at affected life-his stages.
	Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modificat
Hydraulic and								
Geomorphic Modification								
Geomorphic Modification	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : Changes in channel morphology, flow velocity, and substrate composition can affect host fish. <u>Juveniles and adults</u> : As filter feeders,	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project.	May affect survival at all life- history stages and affect life- history stages and productivity host-fish.
Geomorphic Modification Riverine Altered channel	habitat suitability, reduced food web complexity, and reduced	Year-round Year-round (with stressor exposure occurring during high- flow events, fall through spring)		Continuous Seasonal	Juveniles;	morphology, flow velocity, and substrate composition can affect host fish. <u>Juveniles and adults</u> : As filter feeders, constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit	and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the	history stages and affect life- history stages and productivity
Geomorphic Modification Riverine Altered channel geometry	habitat suitability, reduced food web complexity, and reduced	Year-round (with stressor exposure occurring during high- flow events, fall	to long-term Intermediate-term to		Juveniles;	morphology, flow velocity, and substrate composition can affect host fish. <u>Juveniles and adults</u> : As filter feeders, constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition	and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and	history stages and affect life- history stages and productivity
Geomorphic Modification Riverine Altered channel geometry Altered flow velocity	habitat suitability, reduced food web complexity, and reduced	Year-round (with stressor exposure occurring during high- flow events, fall through spring) Year round especially	to long-term Intermediate-term to long-term Intermediate-term to	Seasonal	Juveniles;	morphology, flow velocity, and substrate composition can affect host fish. <u>Juveniles and adults</u> : As filter feeders, constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging	and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the	history stages and affect life- history stages and productivity

			Ex	posure				
ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation	Permanent	Seasonal	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : See related stressor responses under Water Quality Modification.	Avoi throu
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	growth and decay is most extensive)					
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Glochidia larvae; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoi throu
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of	Year-round	Long-term	ong-term Continuous	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : Changes in habitat availability may indirectly affect survival through effects on host fish.	Requ hydra befor perm
		organic matter inputs					<u>Juveniles and adults</u> : Beaver dam removal may modify habitat suitable for juveniles and adults, affecting survival and overall population abundance.	disco habit
	Aquatic Vegetation Modification Riverine							
	Altered autochthonous	Reduced food web productivity,	Year-round	Permanent	Continuous	Juveniles;	Juveniles and adults: Reduced prey	Avoid
	production Altered cover and habitat	reduced foraging opportunity, reduction in available cover				Adults	resources due to decreased food web productivity, decreased growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous production could be expected to affect prey resource availability.	throu
	Riparian Vegetation Modification							
	Riverine							
	Altered stream bank and shoreline stability	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages:</u> Decreased food resource availability, leading to increased competition and resulting effects on growth and fitness for mussels and host fish. Decreased suitable habitat, injury, or mortality caused by excessive turbidity or resulting smothering by burial.	Avoi ripari syste widtl possi

Minimization Measures	Resulting Effects of the Submechanism
void draining impounded area rough use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
void draining impounded area rough use of beaver deceivers.	May affect survival, growth, and fitness of Glochidia larvae, juveniles and adults.
equire assessment of the draulic effects of the project fore permitting and avoid rmitting designs that lead to sconnection of floodplain bitat.	May affect survival at all life- history stages and affect life- history stages and productivity of host-fish.
oid draining impounded area ough use of beaver deceivers.	May affect juvenile and adult survival and productivity.
void/minimize disturbance of parian vegetation. Maintain stem-appropriate riparian buffer dths to the greatest extent assible.	May affect juvenile and adult fitness and survival of mussels and host fish.

ıb-			Ex	posure	1	1			
tivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased sedimentation							
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Glochidia larvae	Mussel dependence upon allochthonous input is a data gap. However, could affect host fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect productivity.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Glochidia larvae; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults:</u> Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects to host-fish could be stressor to these mussels. <u>Juveniles and adults</u> : A physiological response to exposure at toxic levels, causing mortality or injury leading to reduced fitness is a data gap.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect survival of larvae. May affect juvenile survival and adult survival, productivity, and reproductive success.

				posure					Resulting Effects of the
1(Mechanism of Impact Voody Debris ent/Movement/Re nstruction impacts	Stressor smoval (for placement s apply)	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Construction and Maintenance Activities								
	Riverine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Glochidia larvae; Juveniles, Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : The effect of pile- driving sound pressure on California floater and western ridged mussels at any life-history stage is a data gap. Any potential impact would likely occur on the host fish species for the glochidia larvae (California floater= native minnows; western ridge = coldwater stream fish such as trout and salmon).	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Very little is known of the effects of pile-driving sounds on California floater and western ridged mussels any life-history stage.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors un Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile adult life-history stages.

Sub-			Ex	posure	·	·			
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae	<u>Glochidia larvae</u> : Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Any potential impact would only occur if the glochidia fish host is entrained or impinged.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile and adult life-history stages.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Glochidia larvae; Juveniles; Adults;	All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : Changes in channel morphology, flow velocity, and substrate composition can affect host fish. <u>Juveniles and adults</u> : As filter feeders,	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project.	May affect survival at all life- history stages and affect life- history stages and productivity of host-fish.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit	Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the	
	Altered substrate composition		Year round	Permanent	Continuous		prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased	greatest extent practicable.	
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		growth, fitness, and survival.		

ub-			Exj	posure	.	·		1
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Lacustrine							
	Altered wave energy (short- period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Care desi imp proj desi sedi
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult fish. This may occur through increased predation exposure, food web	patte patte
	Altered sediment supply		Year-round	Permanent	Continuous		alterations and decreased foraging	
	Altered substrate composition		Year-round	Permanent	Continuous		opportunity. Effects to host fish affect these mussels.	
	Ecosystem Fragmentation				·			
	Riverine							
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : See related stressor responses under Water Quality Modification.	Req hydi befo
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>Juveniles</u> : See related stressor responses under Water Quality Modification.	-
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : Changes in habitat availability may indirectly affect survival through effects on host fish. <u>Juveniles and adults</u> : LWD removal may permanently modify habitat suitable for juveniles and adults, affecting survival and overall population abundance.	Req hydi befo desi of fl long
	Altered longitudinal habitat connectivity							
	Lacustrine							
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae:Changes in habitatavailability may indirectly affect survivalthrough effects on host fish.Juveniles and adults:LWD removal maypermanently modify habitat suitable forjuveniles and adults, affecting survivaland overall population abundance.	Requ footj obje in ar effec

Minimization Measures	Resulting Effects of the Submechanism
arefully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on diment supply, longshore drift tterns, and wave energy and current tterns.	May affect survival at all life- history stages. Decreased fitness may lead to reduced productivity.
equire assessment of the draulic effects of the project fore permitting	See effects for related stressors under Water Quality Modification.
	May affect survival, growth, and fitness of juveniles and adults.
equire assessment of the adraulic effects of the project fore permitting; avoid permitting esigns that lead to disconnection floodplain habitat or ngitudinal reach simplification.	May affect juvenile and adult productivity and survival.
equire structures with the minimal otprint necessary to achieve project jectives. Avoid permitting projects areas where significant cumulative fects are already prevalent.	May affect survival at all life- history stages and affect life- history stages and productivity of host-fish.

Sub-			Ex	posure					
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	<u>Construction</u> : Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect all life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: Require high levels of dissolved oxygen. See related stressor responses under Water Quality Alteration.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Reduced prey resources due to decreased food web productivity, decreased growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous production could be expected to affect prey resource availability.		May affect all life stages.
							·	·	

			Ex	posure	.				
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Glochidia larvae; Juveniles; Adults	<u>All life-history stages:</u> Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (including food web supporting host fish). <u>Adults and juveniles</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult fitness and survival of mussels host fish.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Glochidia larvae; Juveniles; Adults	All life-history stages: Decreased food resource availability, leading to increased competition and resulting effects on growth and fitness for mussels and host fish. Decreased suitable habitat, injury, or mortality caused by excessive turbidity or resulting smothering by burial.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult fitness and survival of mussels host fish.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased habitat availability and food availability, leading to increased competition and resulting effects on growth and fitness, including health of host fish.	Encourage project designs that limit permanent alteration of high- quality habitat features.	May affect juvenile and adult fitness and survival of mussels host fish.
	Altered groundwater- surface water exchange	Reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Mussel responses to groundwater exchange are a data gap.	Avoid disturbance of vegetation along stream.	Effect of groundwater exchang mussel health and fitness is a d gap.
1	Lacustrine	l					I	1	
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae:</u> Host-fish of the California floater and Western ridged mussel may be affected by increased temperatures, which may lead to mortality or increased thermal stress and decreased fitness of host fish. <u>Juveniles and adults</u> : Mortality due to increased temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect survival of all life- history stages.
_	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for mussel host-fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival.

b-			Ex	posure					
ivity pe	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Mussel dependence on allochthonous inputs from shoreline riparian vegetation is a data gap. This could be a stressor to host fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult growth, fitness, and productivity.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adult	<u>All life-history stages:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and productivity, as well as reproductive success and overall population productivity.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Mussel dependence on groundwater inflow is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long- term (dependent on contributing mechanism of impact)	Continuous to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short- term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects to host-fish could be stressor to these mussels. <u>Juveniles and adults</u> : A physiological response to exposure at toxic levels, causing mortality or injury leading to reduced fitness is a data gap.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of larvae. May affect juvenile survival and adult survival, productivity, and reproductive success.

ty			Ex	posure	1	Ť	4		
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
wni	ng Substrate Aug	mentation							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of elevated anthropogenic noise on California floater and western ridged mussels is a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Very little is known of the effect of elevated anthropogenic noise of California floater and western ridged mussels at any life-history stage.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors unde Water Quality Modification.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when larvae with limited motility are least likely to be present.	May cause direct mortality or injury juvenile and adult life-history stages. Injury and stress may affect survival growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Riverine		<u>_</u>	T	1	T			· · · · · · · · · · · · · · · · · · ·
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Intermediate-term	Continuous	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : Changes in channel morphology, flow velocity, and substrate composition can affect host fish. <u>Juveniles and adults</u> : As filter feeders,	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project.	May affect survival at all life- history stages and affect life- history stages and productivity o host-fish.

Sub-			Ex	xposure	1	- <u>1</u>		
activity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered substrate composition/stability			Short-term to long- term			constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Enc desi chai subs grou grea
	Aquatic Vegetation Modification							
	Riverine							
	Altered autochthonous production	Reduced food resources	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Avoi proje vege habit
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Reduced prey resources due to decreased food web productivity, decreased growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous production could be expected to affect prey resource availability.	-
	Water Quality Modification							
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refu envin area. comj

Minimization Measures acourage selection of project signs that minimize effects on annel geometry, flow velocity, bstrate composition, and oundwater exchange to the eatest extent practicable.	Resulting Effects of the Submechanism
void spawning gravel augmentation ojects in locations where aquatic getation plays a strong role in bitat productivity.	May affect juvenile and adult productivity and survival.
fuel machinery in a controlled vironment away from the project ea. Avoid reducing hydraulic mplexity.	May affect survival, growth, and fitness of juveniles and adults.

Sub-			Ex	posure					
ctivity Type	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids Habitat Creation/Modific	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
II-CII8	Construction and Maintenance Activities	Habitat Creation/Mounic							
	Riverine					/			
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of elevated anthropogenic noise on California floater and western ridged mussels is a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Very little is known of the effects of elevated anthropogenic noise or California floater and western ridged mussels at any life-history stage.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae	<u>Glochidia larvae</u> : Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Any potential impact would only occur if the glochidia fish host is entrained or impinged.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile and adult life-history stages.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Glochidia larvae; Juveniles; Adults;	<u>All life-history stages</u> : See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.

			Ex	posure								
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Water Quality Modification											
	Altered suspended solids	Increased suspended solids (if in- channel project fails)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults:</u> Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adu survival.			
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, ar fitness of juveniles and adults.			
ia	n Planting/Restor	ation Enhancement										
	Construction and Maintenance Activities											
	Riverine and Lacustrine											
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Glochidia larvae; Juveniles; Adults	<u>All life-history stages:</u> Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (including food web supporting host fish). <u>Adults and juveniles</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival and productivity during incubati and rearing.			
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival and productivity.			
		Benthic sedimentation – due to removal of invasive riparian species										

			Ex	posure			_		
vity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification			-					
	Riverine and Lacustrine	1	Γ	Γ	1	I	1	1	
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect all life-history stages.
	Riparian Vegetation Modification								
	Riverine and Lacustrine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect all life-history stages.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Glochidia larvae; Juveniles; Adults	All life-history stages: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (including food web supporting host fish). <u>Adults and juveniles</u> : Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival and productivity during incubation, and rearing.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.

)-			Ex	posure					
ty	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
tlaı	nd Creation Restor	ation/Enhancement							
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of elevated anthropogenic noise on California floater and western ridged mussels is a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Very little is known of the effects of elevated anthropogenic noise of California floater and western ridged mussels at any life-history stage.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile ar adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae	<u>Glochidia larvae</u> : Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Any potential impact would only occur if the glochidia fish host is entrained or impinged.

			Ex	posure					
r ity e	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile an adult life-history stages.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
ach I	Nourishment/Cont	ouring							
		······································							
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term	Interannual to decadal	Glochidia larvae; Juveniles, Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles, Adults	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness. Mortality from burial.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification							•	
	Lacustrine	-			_				
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long- term	Interannual to decadal (depending on activity frequency)	Juveniles, Adults	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness. Mortality from burial.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								

Sub- activity Type	Exposure							l
	Mechanism of Impact	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long- term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Reduced prey resources due to decreased food web productivity, decreased growth and fitness of the California floater and	Av veg Av
	Altered cover and habitat	Reduced cover					Western ridged mussel prey and host fish. Altered autochthonous production could be expected to affect prey resource availability.	pro
	Water Quality Modification							
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short- term (dependent on grain size of augmented sediment)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ens min to c sho bac prac prot turt
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short- term (dependent on contributing mechanism of impact)	Interannual to decadal	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ref con wat

Reef Creation/Restoration/Enhancement

Not Applicable

Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement

Not applicable

Minimization Measures	Resulting Effects of the Submechanism
avoid/minimize disturbance of aquatic egetation during project construction. avoid nourishing beaches updrift of roductive, vegetated aquatic habitat.	May affect all life stages.
Insure project design avoids and/or inimizes habitat alterations leading o chronic shoreline instability. Avoid hort-term turbidity effects above ackground levels to greatest extent racticable. Adhere to established rotocols for managing sediment and urbidity.	May affect juvenile and adult survival.
tefuel and service machinery in a ontrolled environment away from the vater body.	May affect survival and productivity of Glochidia larvae, juveniles, and adults.